

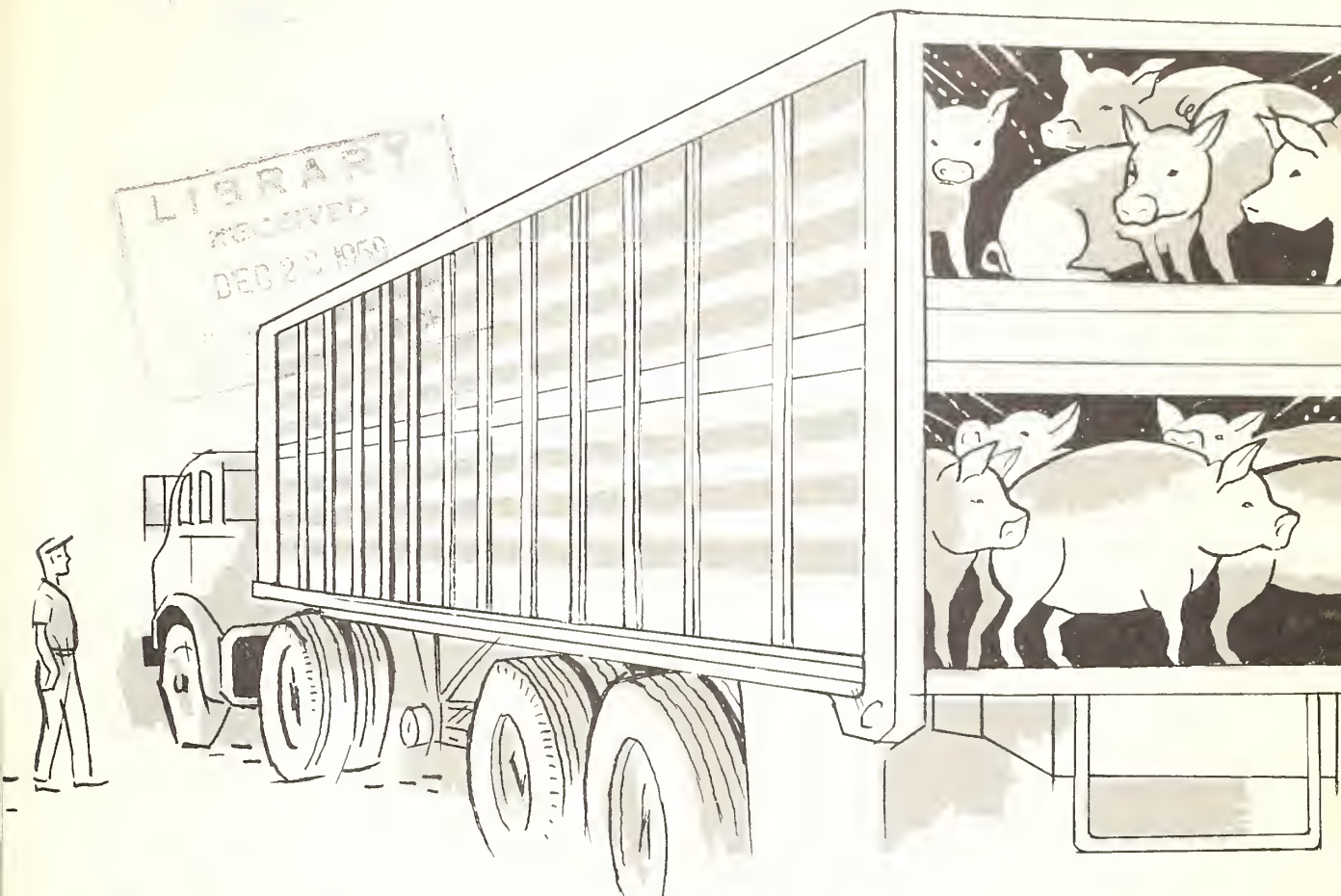




## Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.





# **SPRINKLING HOGS in TRUCKS to reduce losses from heat**

Agricultural Marketing Service      Marketing Research Division  
UNITED STATES DEPARTMENT OF AGRICULTURE

## PREFACE

This study of methods and equipment for sprinkling live hogs with water in transit to reduce shipping losses is part of a broad research program designed to increase the efficiency of marketing farm products.

This report supersedes Marketing Research Report No. 172, "Tests of a Sprinkler System for Hot-Weather Hauling of Live Hogs in Truck-Trailers." Results of later studies are presented here, with a review of the earlier test shipments so as to present a full report of findings.

The study was made under the general direction of Harold D. Johnson, Transportation and Facilities Branch. Cooperation was given by many individuals and companies, including Swift and Company, especially Frank Knutzen; Richard Dickerhoff Livestock Trucking Company; William Oyler, Hoosier Livestock Company; Harry Hennessey, Bloomington Stockyards; H. G. Evans Livestock Trucking Company; Oscar Seaman Livestock Trucking Company; Esskay Packing Company; and N. J. Williams, Smithfield Hog Market.

## CONTENTS

	<u>Page</u>
Summary .....	3
Introduction .....	4
Shipping losses .....	5
Long-haul tests .....	5
Test equipment .....	5
Sprinkling system .....	6
Test procedure .....	17
Results .....	19
Advantages and disadvantages .....	22
Medium-haul tests .....	23
Test equipment .....	23
Sprinkling system .....	23
Test procedure .....	26
Results .....	27
Advantages and disadvantages .....	27
Short-haul tests .....	28
Test equipment .....	28
Sprinkling system .....	29
Test procedure .....	31
Results .....	32
Advantages and disadvantages .....	34
Conclusions and recommendations .....	35
Appendix .....	38

Washington, D. C.

November 1959

For sale by Superintendent of Documents, U. S. Government Printing Office,  
Washington 25, D. C. Price 25 cents.

## SPRINKLING HOGS IN TRUCKS TO REDUCE LOSSES FROM HEAT

By Russell H. Hinds, Jr., and Robert F. Guilfooy, Jr.  
Transportation and Facilities Branch  
Marketing Research Division  
Agricultural Marketing Service

### SUMMARY

In-transit shipping losses of live hogs have been a serious problem in the livestock industry. With increased use of motortrucks, the problem has become acute on long-distance shipments made during hot weather. The purpose of the study on which this report is based was to explore the effectiveness of in-transit sprinkling to reduce these losses.

During a 3-year period, a series of over-the-road comparison tests were made. The possible advantages of sprinkling on 5-, 11-, and 27-hour motor-truck trips were investigated. Mortality (deaths in transit), transit shrink (loss of body weight during transit), and hot slaughtered yield (weight of hot carcass at completion of slaughtering process) were the criteria used. Various sprinkling systems were designed and tested, and evaluations were made of spraying techniques for each length of trip.

Test equipment and operational procedures were selected so as to eliminate variables which could influence the results. In each test, two equal lots of hogs were subjected to the same conditions throughout the test except that one lot was sprinkled in transit, while the other was not. Because of this similar treatment of equal lots, the advantages found can be regarded as a direct result of sprinkling en route.

The long-haul tests (27 hours) yielded the greatest advantage from sprinkling in reducing mortality and transit shrink and in increasing the dressing yield, when the hogs were sprinkled at half-hour intervals and the temperature averaged 81° F. The medium-haul tests (11 hours) showed less advantage when the animals were sprinkled at 2-hour intervals at a temperature of 83°. A total of 31 tests were made over the long and medium distances, resulting in 18 deaths on the unsprinkled trucks and no deaths on the sprinkled trucks. The short-haul tests (5 hours), in which the hogs were sprinkled 3 times en route at a temperature of 77° F., showed no significant advantage from sprinkling.

Two manually operated sprinkling systems and one semiautomatic system were used in the program. Each had some advantages and disadvantages. However, the semiautomatic system was more convenient for the driver to operate and permitted sprinkling at any time desired. This system includes a water reservoir tank and spray nozzles on each deck to cover the entire cargo area.

It operates under 40 pounds pressure from the tractor air compressor and is controlled with a cab-mounted switch that activates an electric solenoid valve. Sprinkling can be done with a minimum of effort at any time the driver deems it beneficial.

This study points to a decided advantage in sprinkling live hogs in transit under certain conditions of time and temperature. It is recommended that any shipper of hogs who operates in summer temperatures above 80° F. consider sprinkling as a means of reducing transit losses.

## INTRODUCTION

In 1917, less than 5 percent of the total number of hogs shipped to market moved by truck. By 1935, this figure had reached about 50 percent, and in 1958, truck shipments accounted for 90 percent of the total movement. This increase in volume has been accompanied by an increase in transportation problems, among the more important of which are mortality and shrinkage losses in hot-weather shipments.

Since swine have no sweat glands to aid in removal of excessive body heat, they are highly susceptible to overheating and crowding in hot weather. The livestock trucker who transports these highly perishable loads faces the problem of maintaining conditions within limits that the hogs can tolerate. One practice which helps to attain this goal is a reduction in the size of load carried. Conversely, the trucker also faces the economic problem of operating his expensive equipment to the fullest extent, and therefore is influenced in the direction of the heaviest payload the vehicle can carry. In these two conflicting factors lies the basic problem of how to haul the heaviest load possible with the least weight loss.

Some truckers have found through experience that "wetting down" the bedding with a hand hose immediately after loading in hot weather, as well as periodically during a long trip, helps to keep the hogs in good condition and reduces mortality. However, the number of truckers who have followed this practice is very limited. The advantages have not been definitely known, and probably have been limited because of the hit-or-miss results of directing a stream of water through the openings in the sides and rear of the truck or trailer. For this reason, research was undertaken to develop and test various methods through which the animals might be sprayed effectively and systematically during their journey to market, and to evaluate the possible benefits in terms of lower incidence of shrinkage, bruising, and death losses during the summer.

During the period 1956-58, over-the-road tests were made on a number of truck-mounted sprinkling systems. This report covers the findings and makes recommendations for the use of such systems.

## SHIPPING LOSSES

Shipping losses between loading of hogs at the shipping point and unloading at destination usually fall into three categories: Transit shrink, mortality, and damage to the carcass from bruising or crippling. It is not always possible to place full responsibility for these losses, since the cause may occur at one time and the resulting loss may not be detected until later. A reliable estimate of the dollar value of these transportation losses is therefore difficult to make.

Livestock Conservation, Inc., a national research and educational organization of the livestock industry, has estimated certain yearly handling losses for swine as follows: Mortality, \$4.7 million; cripples, \$2.1 million; and bruising, \$5.2 million, or a total of \$12 million. <sup>1/</sup> These figures represent losses during the entire marketing period, of which losses in transportation are only a part.

This study is concerned with reducing the losses resulting directly from overheating and crowding during transportation when the temperature is at 80° F. or above. Conservatively estimated, these transportation losses probably account for one-third of the total marketing losses during June, July, and August (one-fourth of the year). This would amount to about \$1 million.

## LONG-HAUL TESTS

The purpose of this series of 15 experiments was to test the operation of a semiautomatic spraying system and determine the advantages of sprinkling in long-distance hauling.

### Test Equipment

Special attention was given to the selection of motor equipment for these tests during the summer of 1958. Four identical tractor semitrailer combinations were chosen in an effort to eliminate the variables created by unlike units. The tandem-axle trailers were 40 feet long, with all-metal sides, double decks, and high ceilings. The tractors were diesel-powered two-axle units, equipped with cab-over-engine sleepers for a two-driver operation. Two of these trucks were equipped with the experimental sprinkling systems, and the other two were used as controls. Figure 1 shows one of the tractor-trailer units equipped with the sprinkling system. In the photograph shown, half of the removable side panels are in place, whereas during the tests all panels were removed to allow full use of side and front ventilation openings.

Temperature recorders were installed on all four vehicles. A recording thermometer was attached to the ceiling of each deck at about the midpoint to

---

<sup>1/</sup> "Livestock Conservation Handbook, 1958," published by Livestock Conservation, Inc., 405 Exchange Building, Chicago 9, Ill.



BN-7493

Figure 1.--One of the tractor semitrailer units used during the 1958 tests, showing underslung reservoir tank mounted at rear.

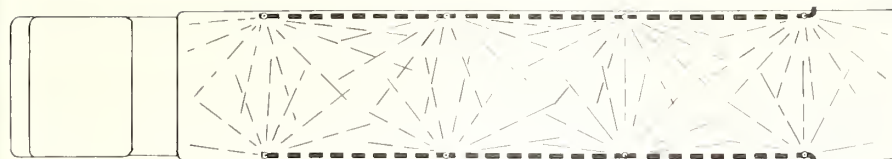
obtain interior temperature data. An additional thermometer was attached to the exterior of two trailers beneath a sunshield to record ambient temperatures. Only two were needed for this purpose, since the trucks operated in pairs.

### Sprinkling System

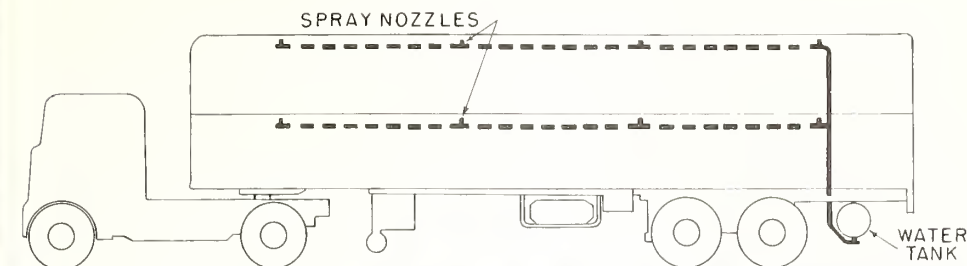
In this series of long-haul tests, a semiautomatic, truck-mounted reservoir-type sprinkling system equipped with spray nozzles was used. Figure 2 shows the general arrangement of this system and figure 3 is a schematic drawing of it. The system was developed on the basis of information gained during the two previous years' work. An 82-gallon heavy-duty galvanized hydropneumatic tank was used as the water reservoir. It measured 20 inches in diameter by 60 inches long, and was rated at 85 pounds per square inch working pressure and 150 pounds test. This tank was mounted beneath the trailer to the rear of the tandem axles. The exact location of the tank mounting may vary with individual trucks to take advantage of uniform weight distribution and axle loadings. Most truckers know from loading experience on which axle they can best afford to carry additional weight.

Heavy iron brackets and straps were used to mount the tank to the trailer. Figures 4, 5, and 6 illustrate the details of this mounting. When a tank of this size is installed, the use of lightweight or substandard materials should be avoided. The tank plus the water weigh about 1,000 pounds. A substantial mount is essential because of the weight of the tank and water plus the ram effect of the water in a partially empty tank.

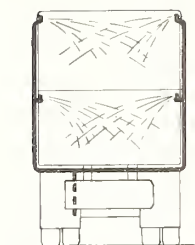
Figure 7 shows installation details of all parts of the sprinkling system except vertical headers and spray headers. The truck airbrake system was used



TOP VIEW



SIDE VIEW



REAR VIEW

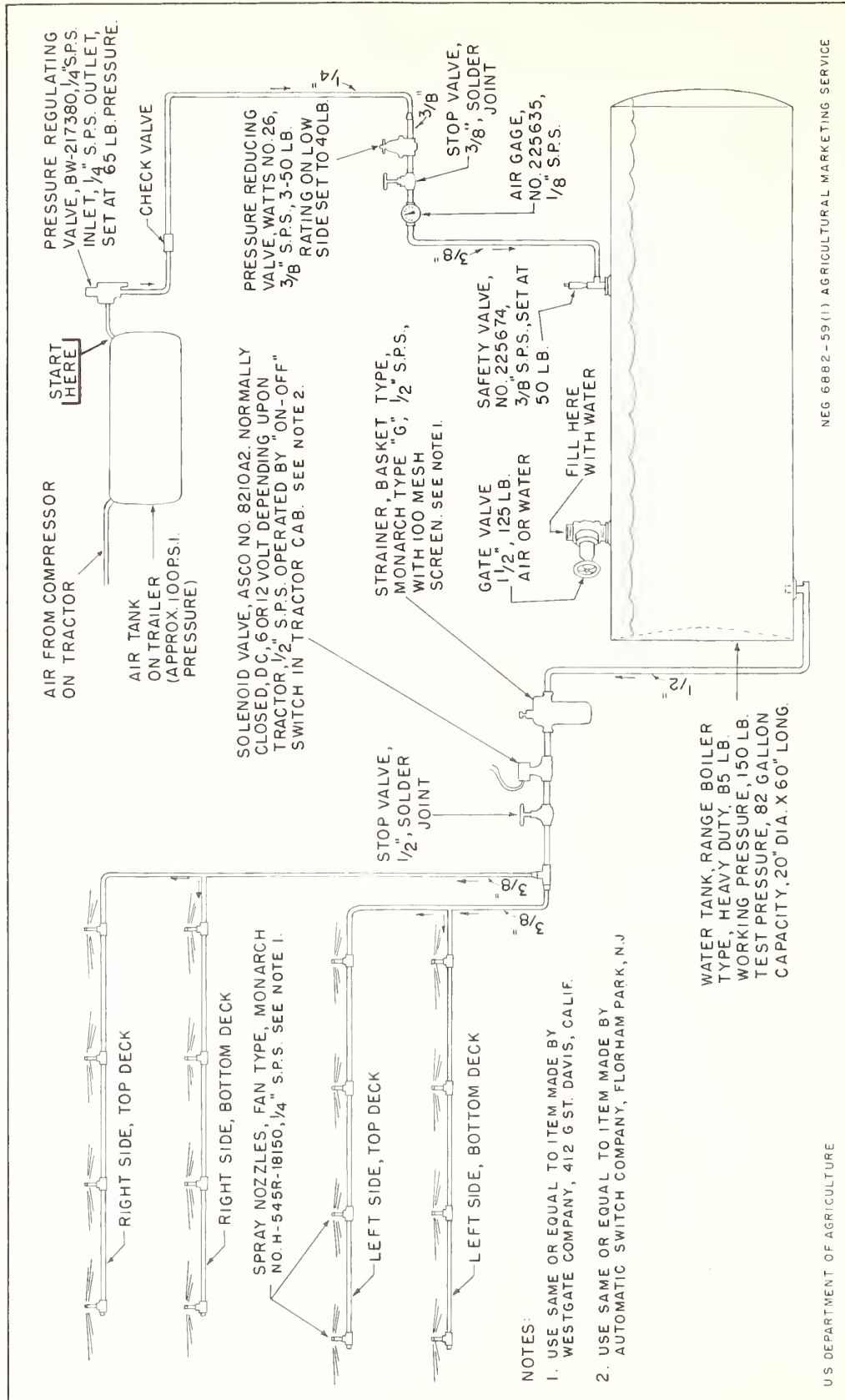
U. S. DEPARTMENT OF AGRICULTURE

NEG. 6879-59(1) AGRICULTURAL MARKETING SERVICE

Figure 2.--General arrangement of sprinkling system used on long-haul tests (1958).

as the source of compressed air to place the water in the reservoir tank under pressure. A line was run from the trailer air tank to the water reservoir tank. A low-pressure cutoff valve (pressure-regulating valve) was placed in this line close to the air tank, as a safety precaution to prevent a complete loss of air for braking purposes in the event of a leak anywhere in the sprinkling system. The valve remains open as long as the operating pressure is above 65 pounds. If the pressure drops below this point, the valve closes automatically and remains closed until the pressure again reaches 65 pounds. A one-way-flow valve (check valve) also was placed in this line to prevent accidental backflow of water into the brake system from the sprinkling system. The third item installed in this line was a pressure-reducing valve. It was used to lower the normal 100-pound braking system pressure to 40 pounds, which proved to be a good operating pressure for the spray nozzles. The regulator was followed by a stop valve, pressure gage, and 50-pound pop-off (safety) valve. An easy method was developed to fasten the gage, stop valve, and pressure-reducing valve to the frame of the trailer so as to reduce vibration damage. The items were first attached to a piece of plywood with small U-bolts, and this in turn was bolted to the frame, as illustrated in figures 7 and 8.

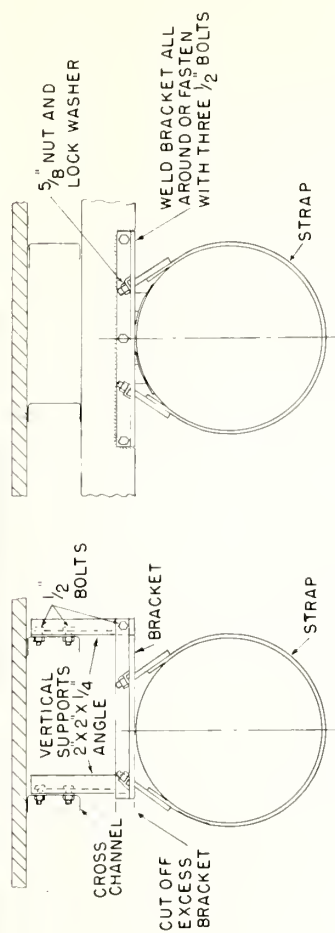
The tank was filled with water through a 1½-inch gate valve, shown in figure 9, rather than through a short nipple and pipe cap. When refilling the tank, which would be under pressure, the driver might forget to release this pressure and receive a severe injury if a pipe cap were used, since it could be hurled with great force when loosened. The gate valve eliminates this hazard, making it possible to release the pressure gradually with little or no danger.



U.S. DEPARTMENT OF AGRICULTURE

NEG 6882-59(1) AGRICULTURAL MARKETING SERVICE

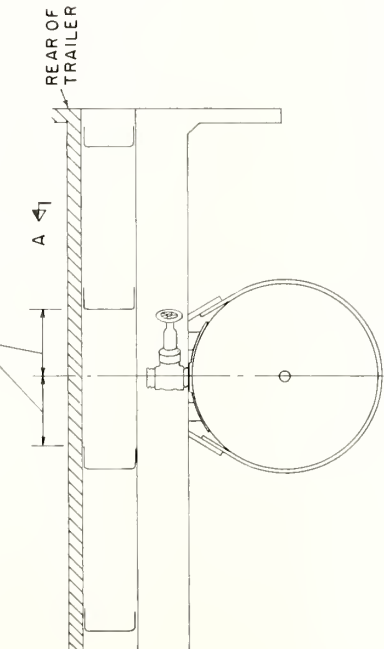
Figure 3.--Schematic drawing of sprinkling system used on long-haul tests (1958).



SECTION B-B

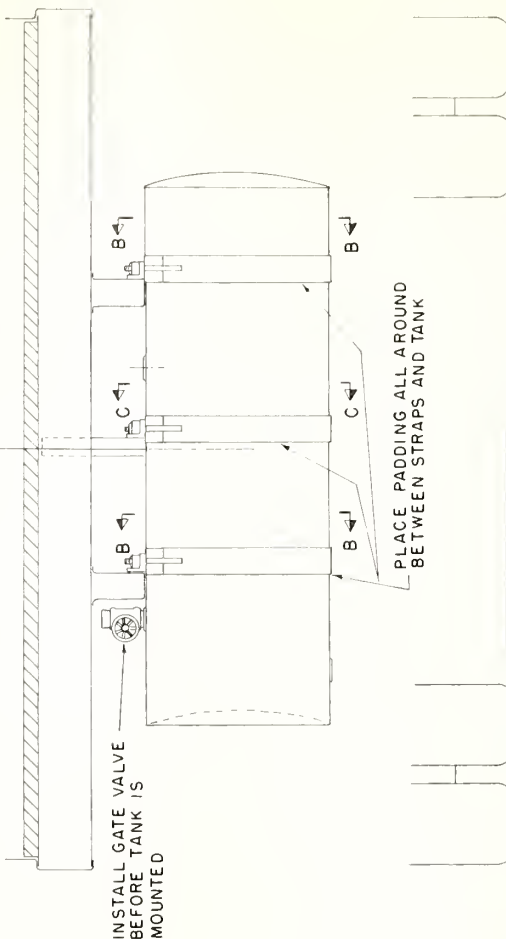
SECTION C-C

EQUAL SPACING TO ALLOW ACCESS  
TO GATE VALVE FOR FILLING TANK



LEFT SIDE VIEW  
U.S. DEPARTMENT OF AGRICULTURE

1/2 OF TANK LOCATE AS NEAR CENTER  
LINE OF TRAILER AS POSSIBLE

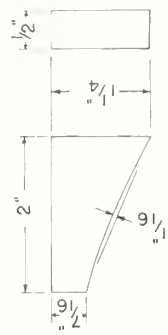


(LOOKING FROM REAR TOWARDS FRONT OF TRAILER)

VIEW A-A

NEG 6883-59 (1) AGRICULTURAL MARKETING SERVICE

Figure 4.--Details of reservoir tank mounting.



(6 REQUIRED)

PART "C"



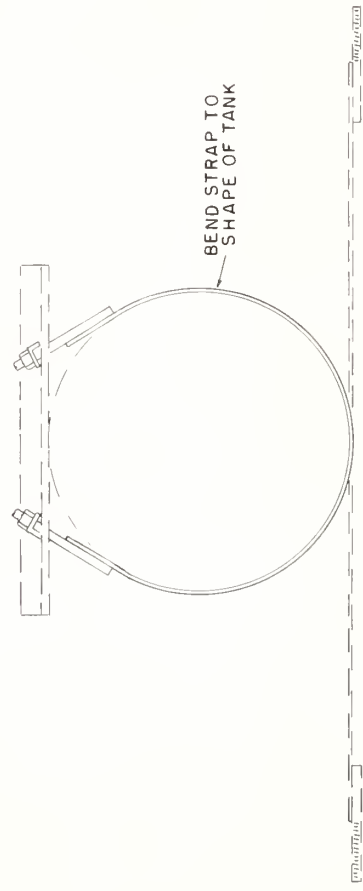
NOTE: PART "A" IS  
SAME AS PART "B"  
EXCEPT FOR HOLE  
LOCATION

(3 REQUIRED)

PART "A"

(3 REQUIRED)

PART "B"



5/8" ROD, 8" LONG  
THREADED FOR 4",  
WELD TO STRAP

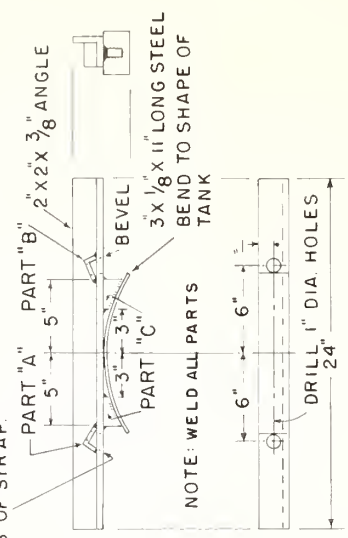
3" x 1/8" STEEL



(3 REQUIRED)

STRAP

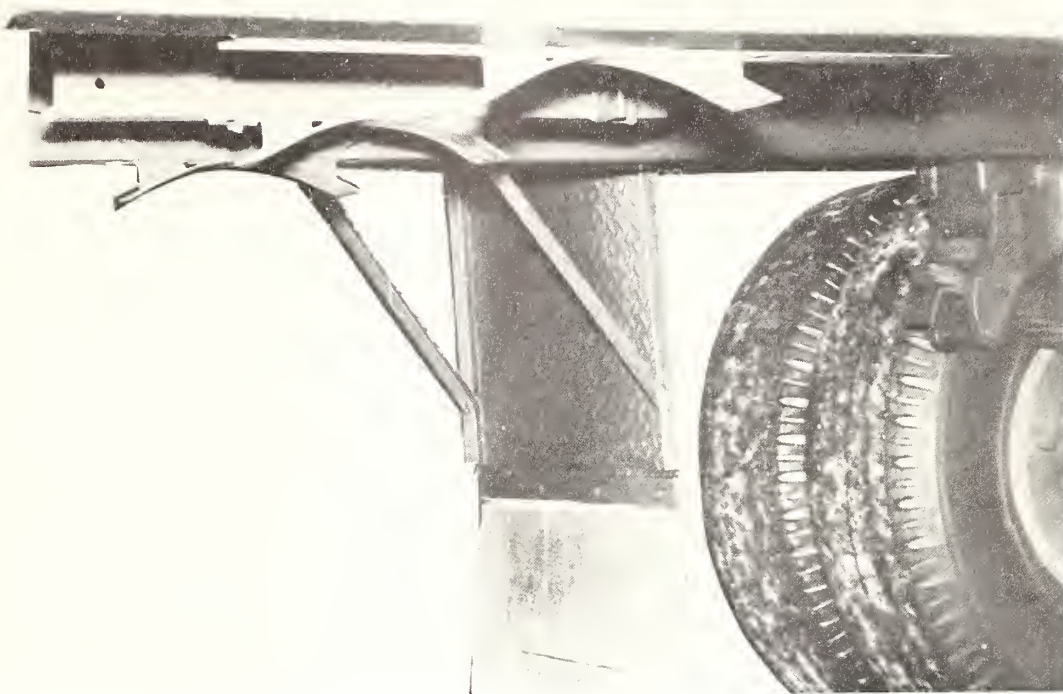
BEVEL SIDE OF BOTH HOLES  
WITH FILE OR TORCH TO  
PREVENT DAMAGE TO  
THREADS OF STRAP.



(3 REQUIRED)

BRACKET

Figure 5.--Details of mounting brackets for reservoir tank.

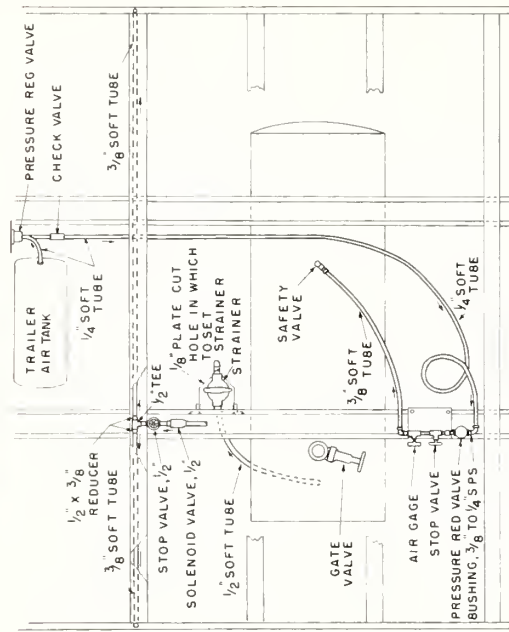


BN-7495-X

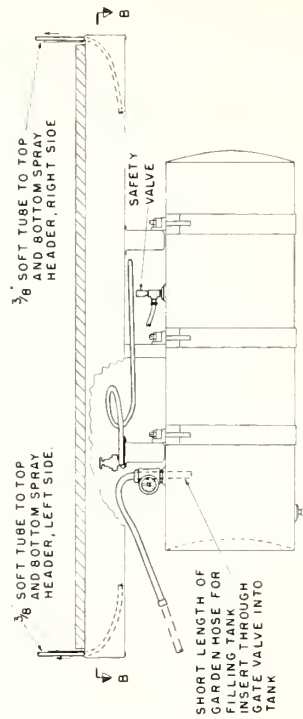
Figure 6.--Tank mounting brackets with tank removed.

During the tests it was found that filling the tank with an ordinary water hose was a slow process. The metal fitting on the end of the hose was too large to go through the filling valve. It rested on the opening of the valve, restricting the flow of air out of the tank as it was being filled with water. To eliminate this problem, the trucker should carry a short length of garden hose (2 feet) which has a threaded fitting on one end only. The other end should be plain, as shown in view A-A of figure 7, so that it can be projected through the filling valve into the tank. This allows the escaping air to pass out of the tank through the space between the sides of the valve and the hose so it will not interfere with the flow of water.

The water line leading from the reservoir tank to the spray line headers on each deck was attached to the lower side of the tank in a tee which also accommodated a drain plug (fig. 7). An undesirable feature developed during the tests because of this design. Small bits of debris which collected in the bottom of the tank were pumped to the solenoid valve and spray nozzles, clogging them both. When the solenoid is clogged, it remains open and allows spraying to continue even though the control switch in the tractor cab is closed. When a spray nozzle orifice is obstructed, it fails to spray and must be removed and cleaned. If the supply of water is not clean or if small solid

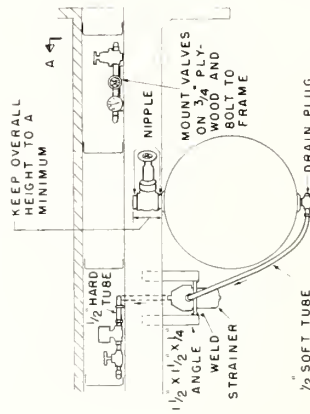


TOP VIEW B-B



(LOOKING FROM REAR TOWARDS FRONT OF TRAILER)

VIEW A-A



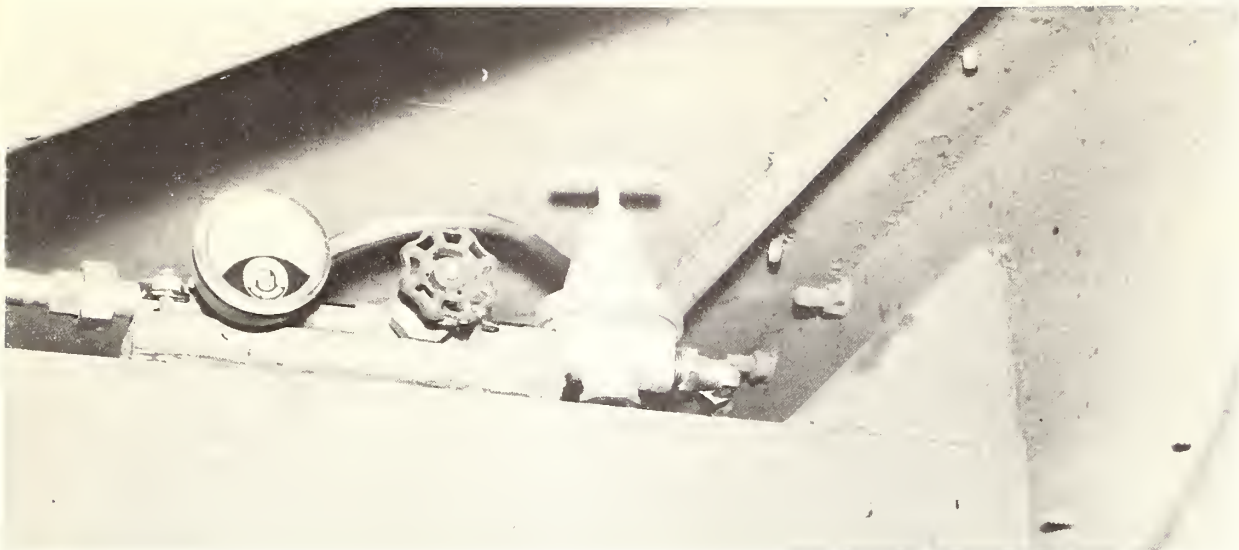
LEFT SIDE VIEW

A-A

NOTES

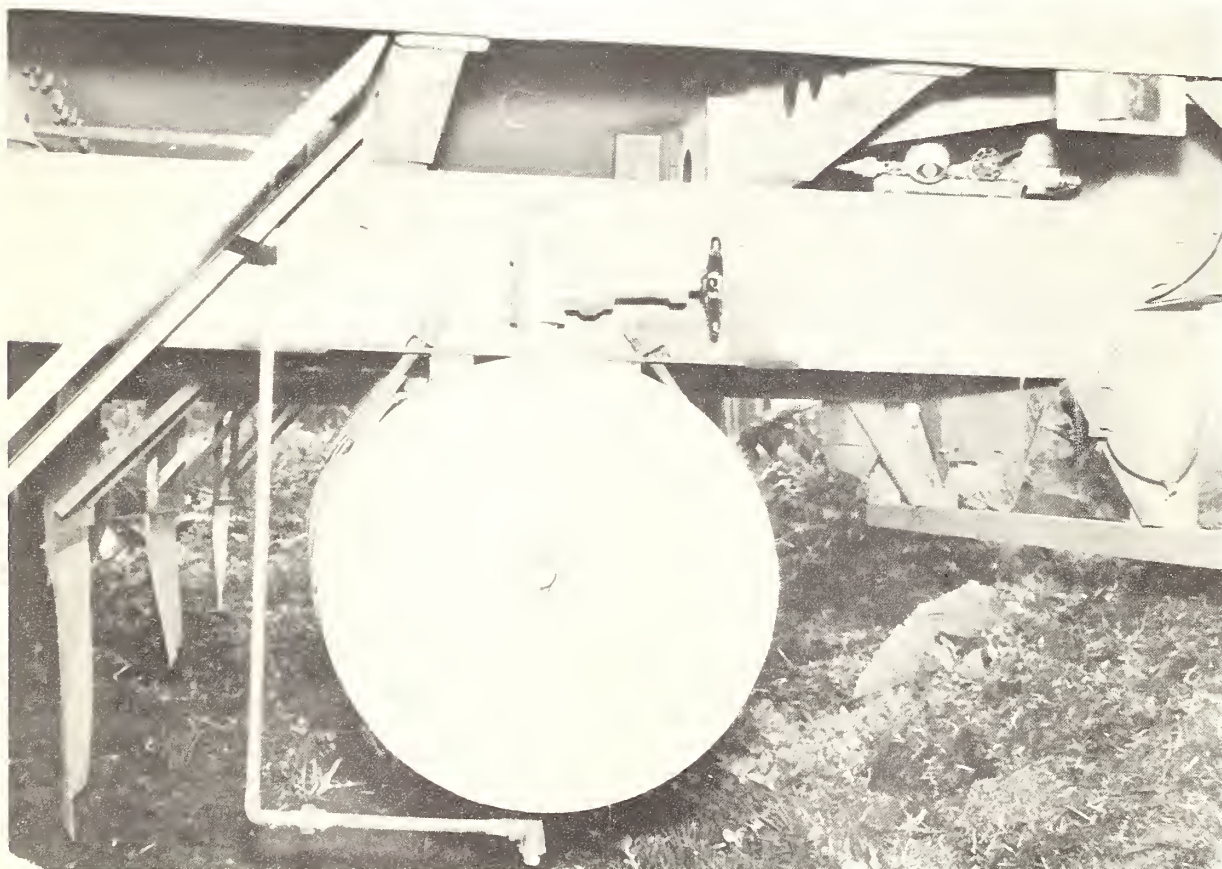
- 1 SEE SCHEMATIC DRAWING FOR COMPLETE DESCRIPTION OF EACH VALVE, GAGE, ETC
- 2 ALL TUBING IS COPPER WATER TUBING TYPE "L" SIZES ARE  $\frac{1}{4}$ " ( $\frac{3}{8}$  O.D.),  $\frac{3}{8}$ " ( $\frac{1}{2}$  O.D.),  $\frac{1}{2}$ " ( $\frac{5}{8}$  O.D.), HARD OR SOFT AS INDICATED
- 3 USE LONG SHANK FERRULE FITTINGS TO FASTEN TUBING TO PIPE THREADS

Figure 7.--Installation details of water tank, valves, and all piping except vertical headers and spray headers.



BN-7492-X

Figure 8.--Method of mounting air gage, stop valve, and pressure-reducing valve.



BN-7491-X

Figure 9.--Side view of mounted tank showing gate valve for filling, feeder line, and air control segments mounted on plywood board.

particles tend to accumulate in the tank, a 100-mesh strainer should be installed in the supply line leaving the tank. The next item in the line is an electrically operated solenoid valve which is normally closed until activated by a control switch in the tractor cab. This valve operates on current from the tractor and must have the same voltage rating as the voltage produced by the tractor.

A  $\frac{1}{2}$ -inch stop valve is placed in the line after the solenoid valve. After leaving the solenoid valve, the water supply line is divided into two smaller lines which run to each side of the trailer adjacent to one of the vertical support posts, as shown in figures 10 and 11. The vertical lines were placed close to the sides of the trailer so as not to interfere with the removable plywood sides which are inserted in slots on the vertical posts during the winter to help protect the animals from the cold. Figure 10 illustrates how the vertical lines were connected to the spray headers to eliminate any undesirable protrusion in the cargo area or to the outside. The spray headers were attached to the inside walls with U-shaped pipe clamps (figs. 10 and 12).

Four spray nozzles producing a fine mist were used on each side of both decks, making a total of 16 nozzles for the entire truck. These were installed in pipe tees at approximately 10-foot intervals along the headers. The fan-shaped spray patterns produced by each nozzle overlapped, giving complete and uniform coverage to the entire cargo areas as shown in figure 2. At 40 pounds pressure, the output of each spray nozzle is rated at 0.18 gallons of water per minute, or 2.9 gallons per minute for the entire truck. This delivery rate proved to be satisfactory. However, with the particular nozzle used, the flow rate could be doubled by removing a small orifice insert from the body of the nozzle.

An on-off switch was installed on the dashboard of the tractor to control the sprinkling by activating the solenoid valve. A hot lead wire was connected to one side of the switch and a wire from the other side was attached to an extra terminal in the tractor-to-trailer electric cable. Most trucks have an extra wire in this cable for special accessories on the trailer. This wire ran to the rear of the trailer, where it was attached to one terminal of the solenoid valve. The other terminal of this valve was grounded to the frame to complete the circuit.

All of the pipe lines and fittings on one test truck were copper. On the other truck, these items were steel, so that a comparison could be made of their cost, ease of installation, and durability. Both steel and copper proved to be satisfactory for the headers. However, the flexible copper lines were more suitable for use from the air supply tank to the water reservoir and from the solenoid valve up the sides of the trailers to the spray lines. In both cases, ease of installation over an irregular pattern made steel pipe or rigid copper undesirable. A protective fibrous loom was used on the copper lines to reduce damage at points where they would be subject to a high incidence of scuffing and abrasion (figs. 11 and 12).

The overall operation of the sprinkling system throughout the tests was good. A few minor changes in design were made and included in these drawings.

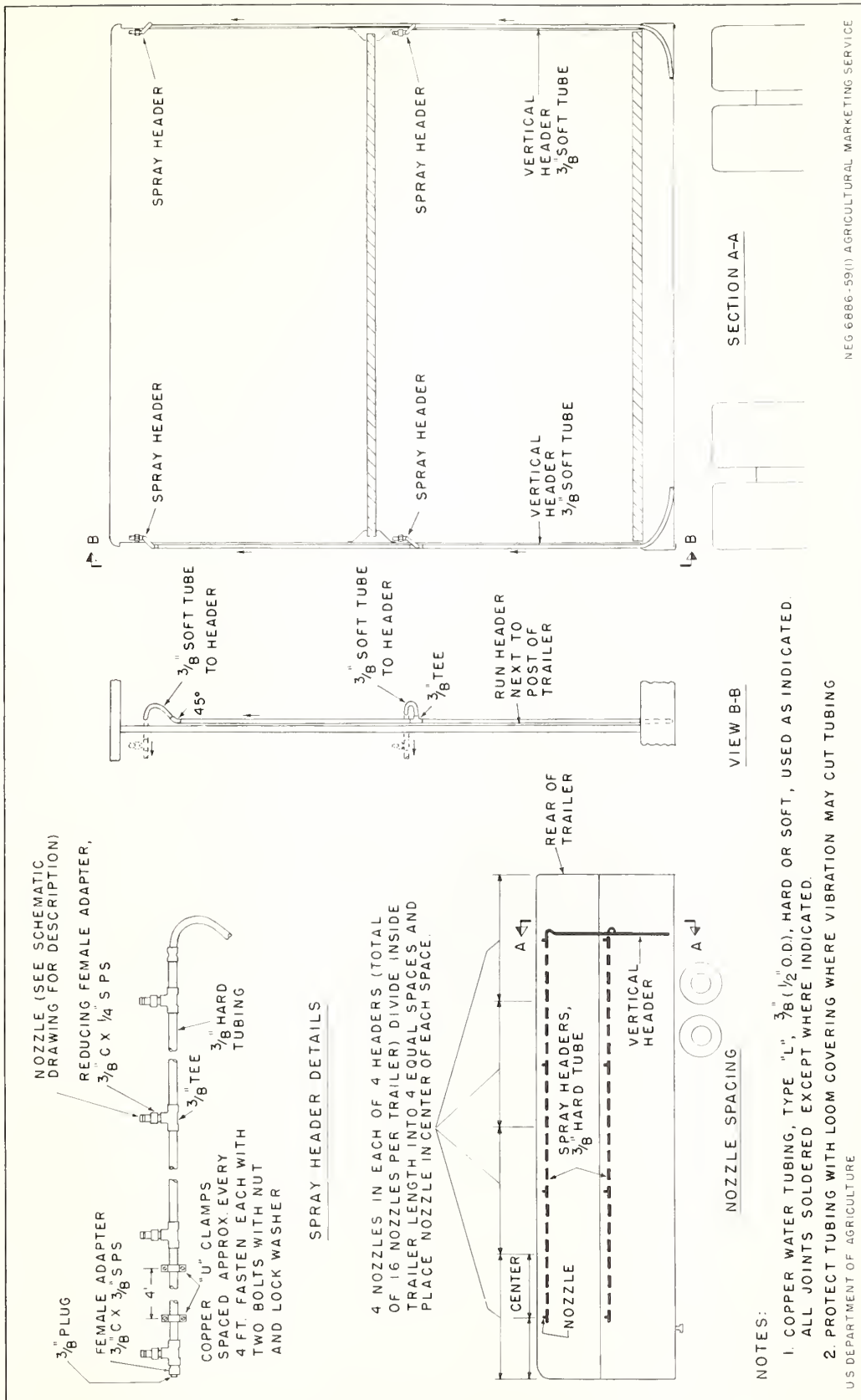


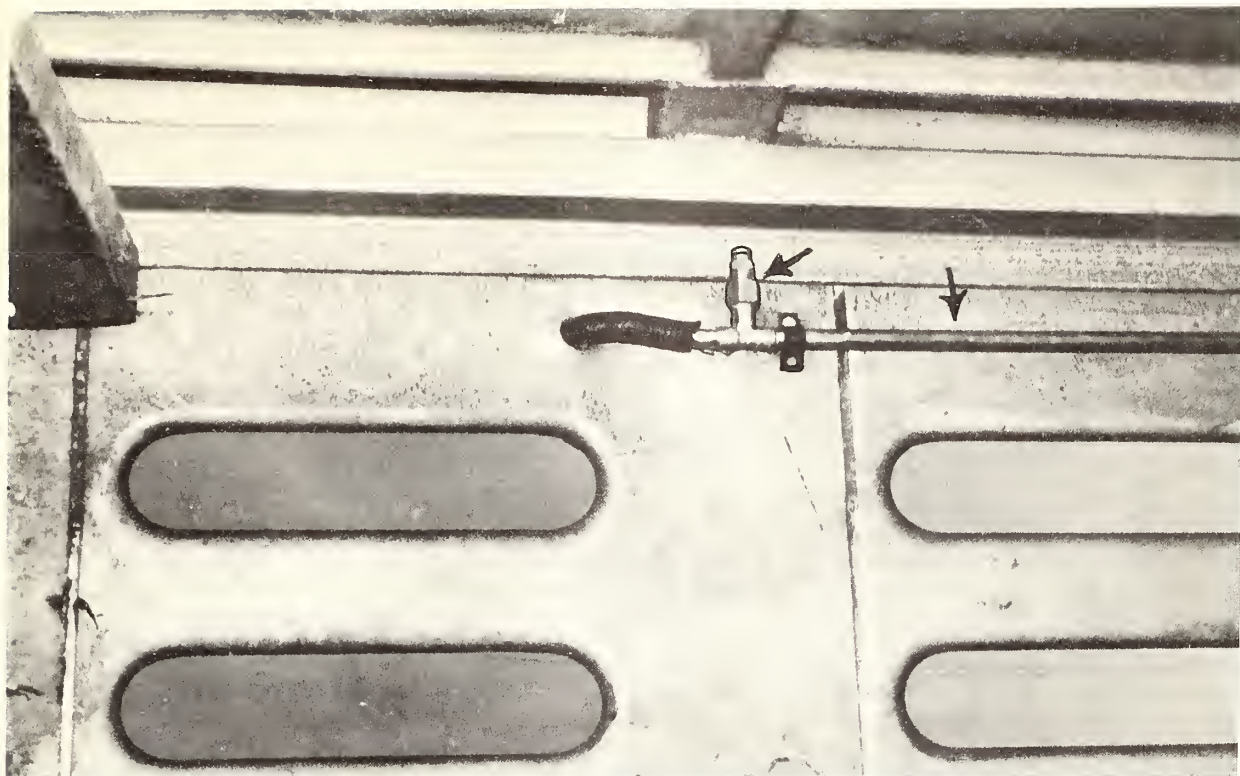
Figure 10.--Details of vertical header and spray header line mountings.



BN-7490-X

Figure 11.--Detail of vertical header line mounting showing use of protective loom on flexible copper tubing.

The only major problem encountered was clogging in the nozzles and solenoid valve, and this could be corrected with the installation of a strainer in the water supply line. The cost for parts on this system was about \$175 and the labor for installation an additional \$125, a total of \$300. The sprinkling equipment added about 400 pounds of weight to the trailer, and with a full supply of water this was increased to almost 1,000 pounds.



BN-7494-X

Figure 12.--Detail of spray nozzle and header mounting showing use of fibrous loom to prevent abrasion damage to flexible copper line.

### Test Procedure

To insure equal treatment to each test lot of hogs and thereby eliminate as many variables as possible, a U. S. Department of Agriculture representative accompanied every shipment throughout the test procedure.

The hogs in these tests came from regular market channels at the Lafayette, Ind., stockyards. No special selection was made except to eliminate cripples or obviously unhealthy animals. Each day the buyer divided his purchases into classes by weight. All of the hogs in the 190-210-pound class were placed in one large holding pen until approximately 300 animals were assembled. These hogs were then reserved for the test and permitted to mix at random while awaiting the trucks, to obtain uniformity of the lots.

Upon arrival of the trucks, all the temperature recording equipment was checked to make certain it was in good operating condition. New charts were placed in the recording thermometers and their accuracy was verified with a hand thermometer. The sprinkling system was tested to be sure that all the parts were operational before loading began.

Sawdust was generally used for bedding on the lower deck and straw on the upper deck. The sawdust appeared to be more satisfactory than straw since straw is inclined to become slippery when moist.

At loading time, half of the animals in the large holding pen were driven to the scales, weighed, and loaded. The remaining group then followed the same procedure. The order of loading the trucks with and without sprinkling systems was alternated each day to eliminate a variable on this point. The first truck to be loaded did not depart immediately, but waited for the second truck. This waiting period was usually about 20 minutes. During this time, the hogs in the truck equipped with the sprinkling system were sprayed for 3 minutes immediately after loading, and then once or twice thereafter, depending on the outside temperature.

During the trip to the slaughterhouse in New Haven, Conn., the two trucks traveled together. The hogs on one were sprinkled en route by the accompanying observer whenever the ambient temperature was 77° F. or above. This temperature was selected on the basis of observations and opinions of veterinarians, research workers, farmers, livestock handlers, and truckers.

The spray period was set first at 1½ minutes, with sprayings a half-hour apart, but after the fifth test the time of spraying was doubled to 3 minutes. The effectiveness of sprinkling lies mainly in the cooling effect obtained by the evaporation of moisture from the animals' skins. It was found that, after the spray was used for 3 minutes while the truck was moving, there was still some moisture on the animals' backs 20 minutes later. Increasing the sprinkling time to more than 3 minutes did not seem to extend the beneficial moisture period, but resulted only in dampening the bedding. Moistened bedding also may have some beneficial cooling effects until it becomes sloppy. Then the benefits may be outweighed by disadvantages which include slippery underfooting, dripping of liquid on the highway, improper weight of load at destination because of particles adhering to skin of the hogs, and unpleasant conditions for the driver at unloading time when he must enter the cargo area to open the partitions or drive out the hogs.

The interval between sprinkling periods was set at one-half hour because the evaporative cooling effect lasted about 20 minutes. In warmer weather, this period might have to be shortened for best results. A combination of a shorter spray period at closer intervals was considered. However, the nuisance factor for the driver may be such that he would neglect to do the job properly if he were required to sprinkle the load every 10 to 15 minutes. Whenever the trucks were delayed en route, traveled through slow traffic, or stopped to refuel, the time between sprinklings was reduced to 5 to 10 minutes, depending on the temperature and the general condition of the hogs at that time. No set rule was followed on this point, because the observers making the decisions on sprinkling time had extensive farm experience and were familiar with handling hogs.

A check was made to determine whether sprinkling while the truck was moving would create a hazard to other vehicles on the highway. This was done by following the test truck with a car. With the car traveling 45 miles per hour and 6 car lengths back of the truck, there was no discernible evidence on the windshield of the sprinkling in the truck ahead. At 2 car lengths back, a slight amount of moisture could be seen but not enough to require use of the windshield wiper. When the car passed the truck in the opposite direction on a 2-lane highway, there was momentary evidence of moisture which quickly disappeared.

The 82-gallon reservoir tank usually provided sufficient water for about fourteen 3-minute spray periods. The tank was filled before loading time and usually once en route. However, on those days when the temperature was highest the tank was refilled twice en route. Water was readily available at all of the regular truck stops and the tank was usually filled while the tractor was refueled.

The travel time for the 950-mile trip varied from 24 to 31 hours, depending on the time of day the trucks passed through the areas of heavy traffic and the number of stops made en route. It was not necessary to stop for the drivers to sleep, since the trucks were equipped with sleeper cabs and manned by two drivers. The trucks usually arrived in New Haven late in the afternoon or evening. On two occasions, however, when the departure from Lafayette was very late, the arrival time was about 4 a.m. the second morning.

On arrival at the slaughterhouse, the trucks were immediately unloaded in the reverse order of loading, and the hogs were weighed and penned under the supervision of a research worker who accompanied each test group of hogs through the slaughtering plant. The over-the-road observer removed the recording thermometer charts, which completed the transit part of the test, and returned to the shipping point for the next test.

The hogs were held overnight and slaughtered early the following morning. The only exceptions to this practice were the two tests that arrived at 4 a.m. These hogs were killed a few hours later. During this holding period, the animals in every test were given water to drink but nothing to eat.

The hogs on test were usually killed as the first two lots of the day, which made it easier to keep them separated from other lots scheduled for slaughter. The observer accompanied each test lot through the entire slaughtering operation, making continual checks along the processing line to ascertain that the test lots did not become mixed. Individual animals which were set aside for trimming or inspection were marked to identify them with their group. As the dressed carcasses crossed the scale, their individual weights were recorded and a total was obtained for the entire lot. At this point, 6 to 10 sample carcasses were selected at random from each lot and tagged with their hot slaughtered yield weights before being placed in the cooler. The following morning these same carcasses were reweighed to verify whether the advantages from sprinkling that resulted in more hot yield would carry through the cooler shrink (loss in weight of carcass during the cooling process).

These procedures were followed on every test, with particular emphasis on uniformity of treatment for each lot, to remove as far as possible any variables between the sprinkled and unsprinkled loads that might affect the validity of the evaluation.

### Results

The sprinkled and unsprinkled test loads of hogs were compared on the basis of mortality, transit shrink, hot-carcass yield, and cooler shrink

(table 2, appendix). In all four categories, the average results favored sprinkling, even though there were five individual tests in which the results were not in favor of sprinkling.

During the long-distance tests, no hogs died in the sprinkled loads 2/, whereas 12 animals died on the 15 unsprinkled trucklots. This average mortality of 0.8 dead hog on each unsprinkled load amounts to a loss of about \$32 3/ per load during the transit period.

Transit shrink was calculated as the percentage of difference between the average loaded weight at the shipping point and the average unloaded weight at the receiving points. The shrink for the unsprinkled loads was 6.74 percent and for the sprinkled 5.63 percent. This advantage of 1.11 percent in favor of sprinkling made it possible for the sprinkled trucks to deliver about 361 pounds per load more live weight than the companion trucks, and represents a saving of about \$72 per load. Following is a comparison of transit shrink for the 15 tests:

<u>Transit shrink per load</u>	<u>Percent</u>	<u>Pounds</u>
Unsprinkled hogs:		
Loss of weight en route of those hogs which arrived alive at destination .....	6.22	2,028
Weight of those hogs which arrived dead at destination .....	<u>.52</u>	<u>169</u>
Total loss of weight en route .....	6.74	2,197
Sprinkled hogs:		
Loss of weight en route of those hogs which arrived alive at destination .....	5.63	1,835
Weight of those hogs which arrived dead at destination (none) .....	<u>0</u>	<u>0</u>
Total loss of weight en route .....	5.63	1,835
Advantage in favor of sprinkling .....	1.11	362

The hot slaughter yield was calculated as a percentage comparing the hot dressed weight with the live weight at the shipping point. The average yield for the unsprinkled lots was 70.75 percent and for the sprinkled 71.31 percent, or an advantage of 0.56 percent for the sprinkled. These figures represent about 182 pounds per load more hot meat on the rail for those shipments which were sprinkled en route, compared to shipments which were not sprinkled.

In calculating the advantage in pounds from the advantage in percentage, a weight of 32,589 pounds was used as the shipping weight. This represents the

2/ See footnote 6 to table 2 of the appendix.

3/ Dollar value estimates throughout this report are made on 200-pound live hogs valued at \$20 per cwt.

average weight of all loads, both sprinkled and unsprinkled, and was selected as a base because it was not possible to have each lot identical in weight at shipping time. Following is a comparison of hot slaughtered yield for the 15 tests:

<u>Hot slaughtered yield</u>	<u>Percent</u>	<u>Pounds</u>
Sprinkled hogs:		
Average yield per load from shipping-point weight to hot-carcass weight .....	71.31	23,239
Unsprinkled hogs:		
Average yield per load from shipping-point weight to hot-carcass weight .....	<u>70.75</u>	<u>23,057</u>
Advantage in favor of sprinkling .....	.56	182

The cooler shrink from hot-carcass to cold-carcass weight was calculated as the loss of weight occurring during the 20- to 22-hour chilling period immediately after slaughtering. This shrink was measured on 6 to 10 sample carcasses in each lot and denoted an average loss of 2.07 percent on the unsprinkled hogs compared to 1.85 on the sprinkled hogs. This advantage is only slight, but it represents a saving of 1/3-pound per carcass, or about 50 pounds more of salable meat per test. Detailed data from the cooler shrink tests are in table 4 in the appendix. Following is a comparison of cooler shrink for the 15 tests:

<u>Cooler shrink</u>	<u>Percent</u>	<u>Pounds</u>
Unsprinkled hogs:		
Average loss in weight per sample carcass from hot to cold yield .....	2.07	3.15
Sprinkled hogs:		
Average loss in weight per sample carcass from hot to cold yield .....	<u>1.85</u>	<u>2.80</u>
Advantage in favor of sprinkling .....	.22	.35

Comparisons could not be made of losses which stemmed from bruising damage during transit, because it was not possible to ascertain whether the animal was bruised before loading. There is probably a reduction in the incidence of bruising when the hogs are sprinkled during hot weather. They are more comfortable and there is less jumping and moving about, which reduces the probability of damage. The advantage of sprinkling was particularly noted by the accompanying observer on 4 occasions, when a total of 13 animals on the unsprinkled truck had to be helped off the truck at unloading. These animals were suffering from heat prostration and could not walk unassisted. General

observation made on all the tests indicated the sprinkled lots were more lively at unloading than the unsprinkled ones. Observations made immediately after loading indicated less time was required for the sprinkled animals to become settled and quiet from the rigors of driving and loading than for the unsprinkled control groups. On hot days, it was further observed that the control groups never became quiet or settled. They were continually moving, jumping, and pushing in an effort to escape the heated and crowded conditions into which they had been placed.

One crippled animal was delivered on a sprinkled truck and one on an unsprinkled truck during the tests. This low incidence of crippled animals made the loss insignificant, so it was disregarded in the results.

The average recorded outside temperature during these tests was 73.3° F., whereas the average inside deck temperatures were 74.3° F. for the sprinkled loads and 76.6° F. for the unsprinkled. Detailed temperature data for individual tests are in table 3 in the appendix. This table also shows that the average load received 16 sprinklings en route and that the average temperature was 81° F. at the time of sprinkling.

#### Advantages and Disadvantages

The semiautomatic sprinkling system, using a reservoir tank and spray nozzles, has these advantages:

1. The hogs can be sprinkled at any time during transit when the cooling effect will be advantageous, that is, when the temperature is high, during delays in loading or unloading, in case of breakdown, through slow city traffic, etc.
2. Sprinkling requires little effort on the part of the driver, since it is done by the turn of a switch in the cab.
3. The water reservoir tank has sufficient capacity to minimize stops for refilling.
4. The patterns formed by the spray nozzles give complete and effective coverage to all of the cargo area, with low gallonage output.
5. Pressure for sprinkling is always uniform and readily available as long as the tractor motor is operating. In case of a breakdown, a passing truck could be stopped to supply a pressure charge to the reservoir which would last for several hours.
6. Maintenance cost is nominal because of the rugged construction and few moving parts of the equipment.

The two major disadvantages of the system are the initial cost and the added tare weight which reduces the size of payload that can be carried. The first of these can be justified by the truck owner on the basis of the savings

from a reduction in claims for the value of animals which die in transit during hot weather. The second disadvantage, added weight, exists only in the summer, since the system can be fully or partially removed in cold weather so that the trucker can carry his normal payload. During the summer, most shippers reduce the size of the loads they ship to minimize mortality and shrink. For this reason, many truckers are not given maximum loads and the additional weight of the sprinkling system need not result in a loss of payload.

## MEDIUM-HAUL TESTS

During the summer of 1956, the effectiveness of sprinkling live hogs in transit was investigated on a daytime trip of 11 hours. Detailed results of the work were published in May 1957 and are available in Marketing Research Report No. 172. 4/

### Test Equipment

Two similar tractor semitrailer units equipped with manually operated sprinkling systems were used in these tests. Recording thermometers were installed on each unit to collect interior and exterior temperature data.

### Sprinkling System

The general arrangement of the spray system tested is shown in figure 13. It was manually operated, and water for sprinkling was obtained at truck stops along the route. A garden hose, connected to a fitting on the truck, supplied two  $\frac{1}{2}$ -inch pipe headers attached to the center of the ceiling on each deck. These pipes extended the entire length of the truck and were drilled with numerous small holes through which streams of water flowed to provide the cooling spray. Details of construction are illustrated in figures 14 and 15. The metal pipe, with  $\frac{5}{64}$ -inch holes 16 inches apart, produced large streams of water which were not so effective as a finer spray and wasted much of the water.

Toward the end of the tests, a plastic "lawn-soaker" hose was substituted for the  $\frac{1}{2}$ -inch steel header pipes (figs. 16 and 17). This change was made in an attempt to provide better spray coverage of the cargo area at a lower initial cost. The low-cost soaker hose provided a large number of very small holes which produced a fine mist-like spray over all of the animals.

The soaker hose shown in figures 16 and 17 was installed on an additional experimental model and not used as part of the test equipment. The cost of installation of the steel pipe system was about \$75 and of the plastic hose about \$35.

---

4/ Guilfooy, Robert F., Jr., Tests of a Sprinkling System for Hot-Weather Hauling of Live Hogs in Truck-Trailers. U. S. Dept. Agr., Mktg. Res. Rept. 172, 20 pp., illus. May 1957.

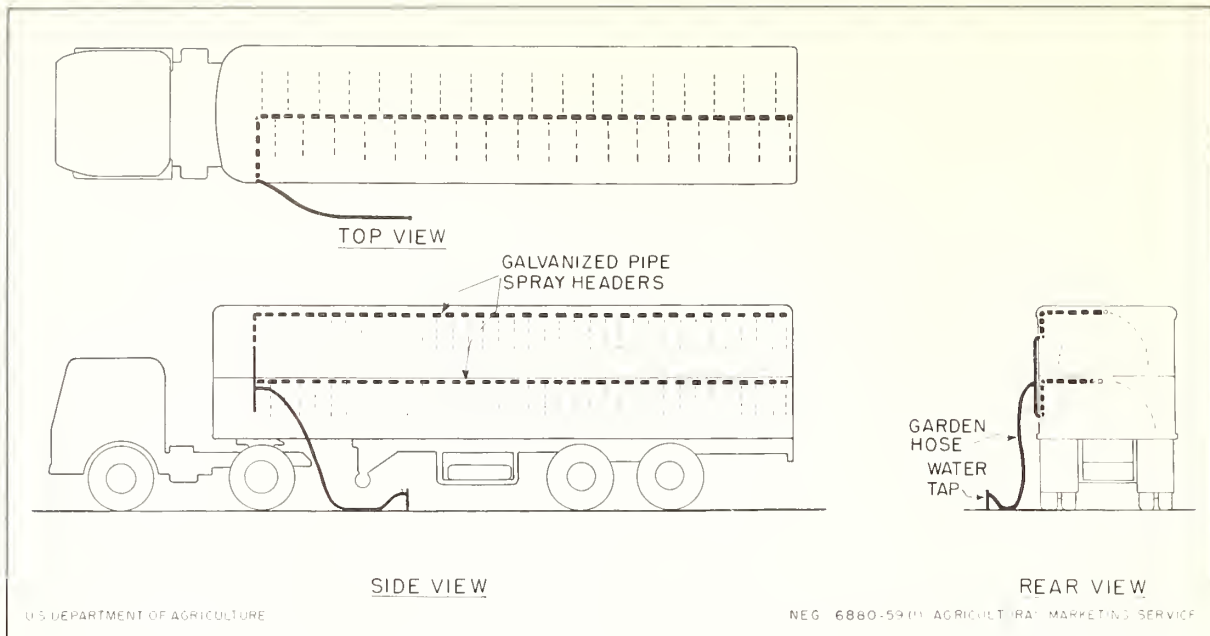


Figure 13.--General arrangement of sprinkling system used on medium-haul tests (1956).

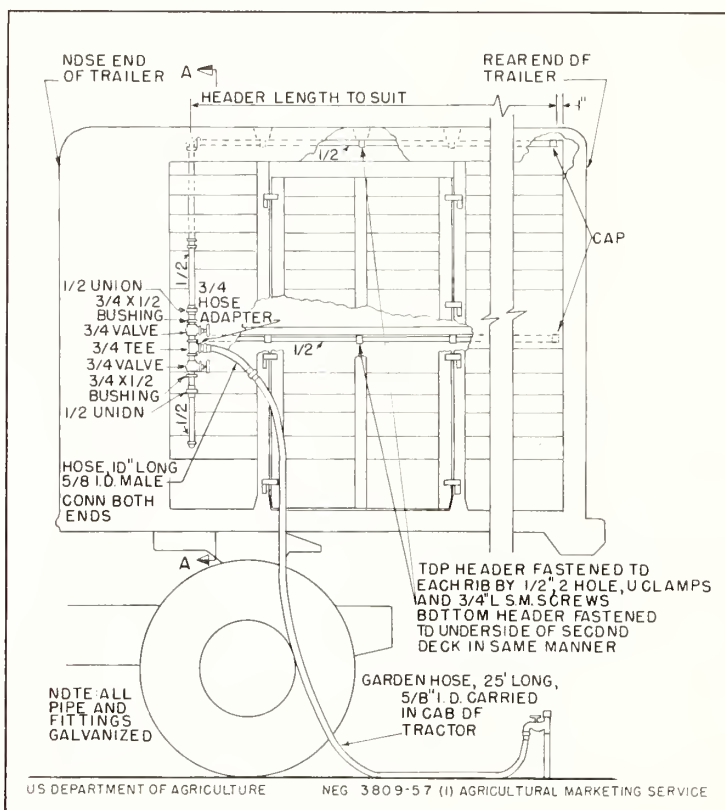


Figure 14.--Details of piping in sprinkler system used on medium-haul tests (1956).

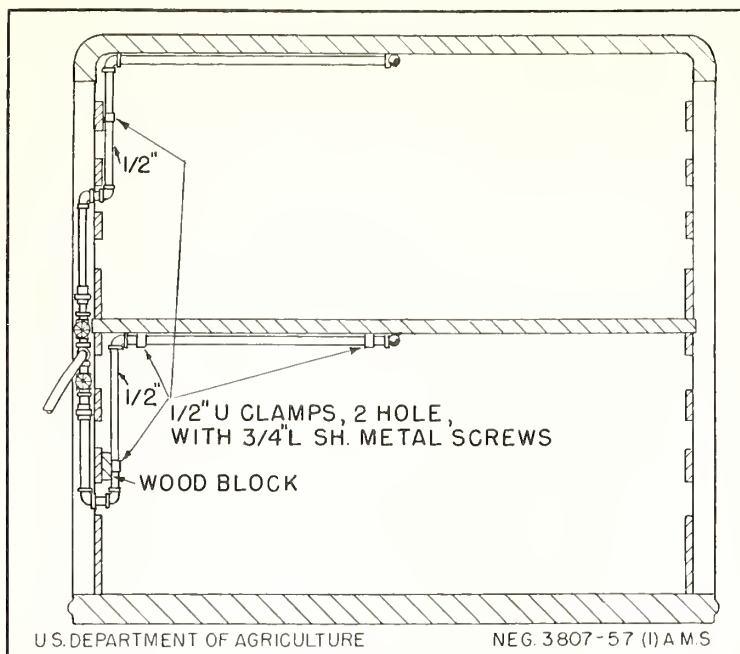


Figure 15.--Cross section A-A of figure 14.

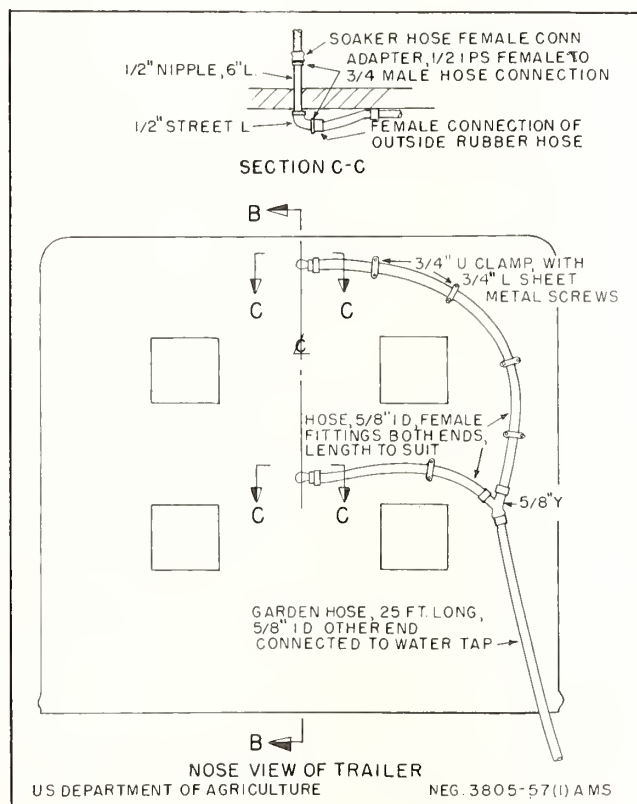


Figure 16.--Outside arrangement of  
soaker-hose sprinkler system.

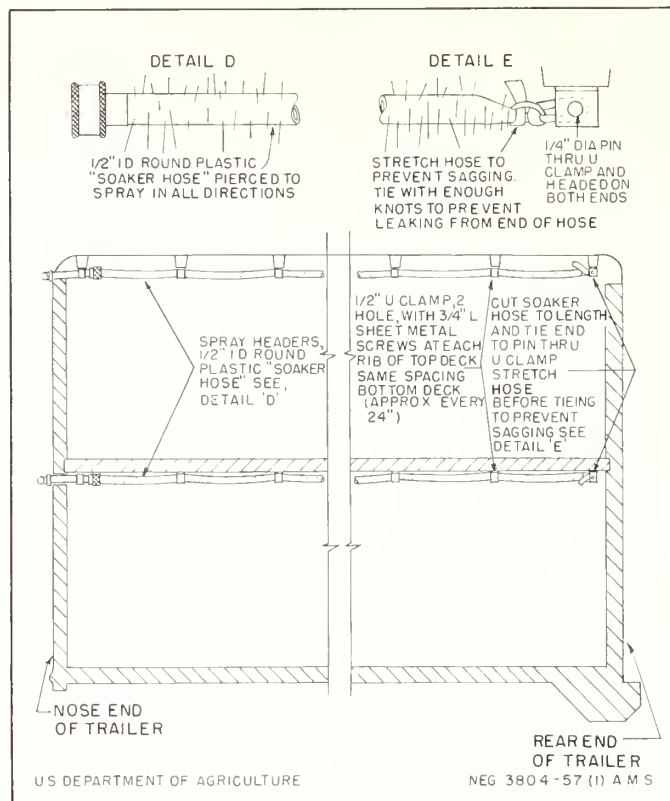


Figure 17.--Section B-B of figure 17 showing inside arrangement of soaker-hose sprinkler system.

### Test Procedure

This series of 16 tests was conducted with the same general procedures described in this bulletin for work in 1957 and 1958. Equal lots of hogs were shipped on similar trucks from Smithfield, N. C., to Baltimore, Md. Each test consisted of two truckloads of hogs, one of which was sprinkled en route at 2-hour intervals for 10 minutes each time. The other truckload was not sprinkled and acted as the control. Both units traveled together so that the hogs were subjected to the same environmental conditions. The question may arise as to whether the unsprinkled truck may have given better results if it had traveled straight through instead of stopping at the same time as the sprinkled truck. From observation it appears that truck drivers, in general, stop about every two hours to eat, gas up, etc. Therefore, the unsprinkled truck was probably not operating under unusual conditions.

The test procedures were supervised by USDA representatives at both the shipping and receiving points, and approximately half of the test loads were accompanied by an observer.

## Results

The average ambient temperature during the trips was 80.4° F., and the average ambient temperature at times hogs were sprinkled was 83°. The results obtained from these tests revealed the following average advantages per truckload in favor of sprinkling:

<u>Transit shrink</u>	<u>Percent</u>	<u>Pounds</u>
Unsprinkled hogs:		
Loss of weight en route of those hogs which arrived alive at destination .....	2.97	652
Weight of those hogs which arrived dead at destination .....	<u>.33</u>	<u>72</u>
Total loss of weight en route .....	3.30	724
Sprinkled hogs:		
Loss of weight en route of those hogs which arrived alive at destination .....	2.27	498
Weight of those hogs which arrived dead at destination (none) .....	<u>0</u>	<u>0</u>
Total loss of weight en route .....	2.27	498
Advantage in favor of sprinkling .....	1.03	226

<u>Hot slaughtered yield</u>	<u>Percent</u>	<u>Pounds</u>
Sprinkled hogs:		
Average yield per load from shipping-point to hot-carcass weight .....	79.37	17,429
Unsprinkled hogs:		
Average yield per load from shipping-point weight to hot-carcass weight .....	<u>78.90</u>	<u>17,326</u>
Advantage in favor of sprinkling .....	.47	103

During the tests, six hogs arrived dead at the slaughterhouse on unsprinkled trucks and there were no dead animals on the sprinkled trucks.

## Advantages and Disadvantages

This sprinkling system with a single spray header installed on the ceiling of each deck is most practical for those truckers who transport hogs exclusively, leaving their deck boards intact. If the deck boards are removed regularly

to haul cattle or dry freight, it would be impractical to remove the steel pipe spray headers each time. The plastic soaker-hose model, however, might be utilized when the deck boards were occasionally removed if some caution were exercised in its removal.

This system, with either metal or plastic spray headers, has the disadvantage of being manually operated and of not carrying its own water supply, so that stops must be made to sprinkle the load. Its merits, however, lie in the economy of installation and practicability for occasional or intermittent use. Many truckers could reduce shrink and death losses in hot weather by the conscientious use of this device.

Advantages and disadvantages of this system were:

Advantages:

1. Low initial cost.
2. Ease of installation (particularly the lawn-soaker hose).
3. Light in weight.
4. Low maintenance.
5. Low replacement cost for lawn-soaker hose.
6. Well adapted for occasional use.

Disadvantages:

1. Dependent on outside water supply.
2. Spraying can be done only when truck is stopped.
3. Owners of some roadside business places would object to livestock trucks parking to spray the load.
4. Sufficient water pressure is not always available for complete coverage of both decks simultaneously.
5. The spray streams deliver a larger total volume of water than spray nozzles. Most of this excess is ineffective and wasted.
6. Drivers are reluctant to stop and spray as often as they should, because of the time consumed and the extra effort required to hook up the water supply.
7. Deck boards cannot be removed without first removing the spray headers.

## SHORT-HAUL TESTS

Field tests were conducted in 1957 to explore the possible benefits of sprinkling live hogs on a 5-hour motor trip during the evening or at night. These conditions were selected because a large percentage of midwestern hogs move to market in this manner. A modification of the 1956 sprinkling system also was evaluated concurrently with these tests.

### Test Equipment

Two trucking companies supplied tractor semitrailer units for use in this series of tests. One company, operating from Bloomington, Ill., provided

two identical units. Each tandem-axle trailer was 39 feet long and had wooden sides and double decks. The tractors were of the same model, gasoline powered, and equipped with conventional cabs. One of these units is shown in figure 18. The second company, operating from Mattoon, Ill., supplied similar trailers, each 32 feet long, with double decks. The tractors were of different makes but each was powered with a gasoline engine and had a conventional cab. Recording thermometers were placed on each unit to collect interior and exterior temperature data.



BN-7497

Figure 18.--One of the tractor semitrailer units used on short-haul tests in 1957.

### Sprinkling System

The four test vehicles were equipped with manually operated sprinkling systems. Figure 19 illustrates the components of the systems and their arrangement on the trailer.

Water for sprinkling was supplied from an outside source by attaching the hose carried on the trailer to a water faucet. When the faucet was turned on, the water moved through this hose to the front of the trailer where it was divided into the four header lines extending the entire length of the cargo area. Figures 20 and 21 are interior and exterior views of this design. The header lines were made of  $\frac{1}{2}$ -inch plastic pipe and attached with pipe clamps high on both side walls of each deck. The plastic pipe was pierced with a pin at 3-inch intervals along its entire length to provide openings through which small streams of water could pass to provide the cooling spray. Every alternate hole was drilled horizontally to the floor and toward the centerline of the floor. The pinholes were placed in the pipe so as to direct the spray streams for uniform coverage of the entire cargo area, as shown in figure 19.

Cost of material to construct this sprinkling system was about \$30, and the labor for installation an additional \$60.

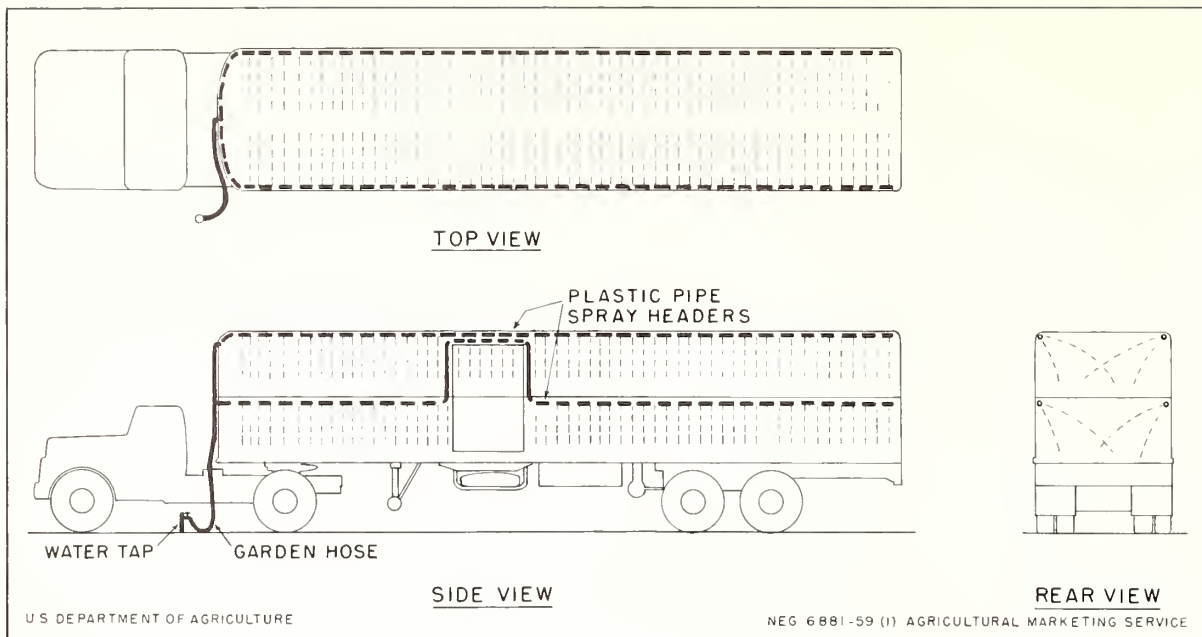


Figure 19.--General arrangement of sprinkling system used on short-haul trips (1957).



BN-7498

Figure 20.--Inside arrangement of plastic pipe spray headers on sidewalls of each deck.



BN-7496

Figure 21.--Piping and hose on nose of trailer to supply water for top and bottom spray headers.

### Test Procedures

Two shipping points were selected in an effort to obtain a maximum number of tests during the 1957 summer season. The shipments originated in Bloomington and Mattoon, Ill., and both terminated at the East St. Louis, Ill., stockyards. The average length of haul was about 140 miles, requiring approximately 5 hours for the trip.

Animals selected for the test lots were taken from the regular purchases made at the stockyards in both Mattoon and Bloomington, Ill. They were placed in groups according to their weights, which varied from 180 pounds for light butcher hogs to over 350 pounds for sows. These mixed lots were penned separately until loading time, when each group was divided in halves, weighed, and an equal number placed on both the sprinkled and unsprinkled trucks. The loads averaged 125 animals per truck.

Various materials were used for bedding throughout the tests, including sand, sawdust, cinders, corncobs, and straw. Sand and sawdust gave the best results for bedding and were commonly used. However, on the few occasions when neither was available, the other less desirable beddings were employed.

The order of loading was changed each day. This was done to equalize any detrimental effects which may have developed during the waiting period after

the first truck was loaded, while it awaited the loading of the second truck. Loading was generally completed between 5:00 p.m. and 7:00 p.m. whereupon one lot was sprinkled for 10 minutes before departure.

En route to the slaughterhouse, the trucks from each shipping point traveled in pairs. The animals were sprinkled twice during the trip, for 10 minutes each time, whenever the outside temperature was 70° F. or above. The spraying was done by a USDA representative approximately 1½ and 3½ hours after departure from the shipping point. Upon arrival at the slaughterhouse stockyards, each lot was immediately unloaded, weighed, and penned to await slaughter the following morning. During this overnight holding period, the hogs were given water to drink but nothing to eat. They were also sprinkled in the pens during the night whenever the temperature was high, since this was the usual method of handling all lots of hogs in the yards.

The test shipments were slaughtered as the first lots handled in the processing plant each morning. They were accompanied by an observer to insure the maintenance of lot identity. Carcass weight data, for calculating dressing yields, were taken from the scale recording tapes as processing of each lot was completed.

### Results (1957)

Data collected from the 23 tests originating in Bloomington, Ill., revealed only slight advantages of .23 percent for transit shrink and .07 percent for hot dressed yield, in favor of sprinkling. The 22 Mattoon tests showed even less advantage, .19 percent advantage for transit shrink and a disadvantage of .07 percent in hot slaughtered yield. The average ambient temperature during the trips was 76° from Bloomington and 75° from Mattoon, and the average ambient temperature when hogs were sprinkled was 77°. These results indicate there is no advantage to spray cooling of hogs in transit on a trip of 5 hours when the temperature is 77°. Sprinkling at this temperature or lower may even serve to chill the animal, causing an increase in the hog's metabolism to maintain a comfortable body temperature. An increase in metabolic rate usually results in the use of stored fats and a loss of body weight.

Data for the Bloomington tests are given in tables 5 and 6 in the appendix. Data for the Mattoon tests are given in tables 7 and 8 in the appendix. The method of calculation of transit shrink and hot slaughtered yield was the same as that used for the 1958 tests.

The following figures summarize the transit shrink data collected from all tests in the 1957 season:

Transit shrink, Bloomington, Ill.PercentPounds

## Unsprinkled hogs:

Average loss of weight per load from shipping point to receiving point, including dead hogs..	2.97	838
---	------	-----

## Sprinkled hogs:

Average loss of weight per load from shipping point to receiving point, including dead hogs..	<u>2.74</u>	<u>774</u>
---	-------------	------------

Advantage in favor of sprinkling .....	.23	64
--	-----	----

Transit shrink, Mattoon, Ill.PercentPounds

## Unsprinkled hogs:

Average loss of weight per load from shipping point to receiving point, including dead hogs..	3.23	883
---	------	-----

## Sprinkled hogs:

Average loss of weight per load from shipping point to receiving point, including dead hogs..	<u>3.04</u>	<u>831</u>
---	-------------	------------

Advantage in favor of sprinkling .....	.19	52
--	-----	----

The following figures summarize the hot slaughtered yield data collected from all tests in the 1957 season:

Hot slaughtered yield, Bloomington, Ill.PercentPounds

## Sprinkled hogs:

Average yield per load from shipping-point weight to hot-carcass weight .....	78.29	22,111
---	-------	--------

## Unsprinkled hogs:

Average yield per load from shipping-point weight to hot-carcass weight .....	<u>78.22</u>	<u>22,092</u>
---	--------------	---------------

Advantage in favor of sprinkling .....	.07	19
--	-----	----

Hot slaughtered yield, Mattoon, Ill.PercentPounds

## Sprinkled hogs:

Average yield per load from shipping-point weight to hot-carcass weight .....	77.71	21,246
--	-------	--------

## Unsprinkled hogs:

Average yield per load from shipping-point weight to hot-carcass weight .....	<u>77.78</u>	<u>21,265</u>
--	--------------	---------------

Advantage in favor of not sprinkling .....	.07	19
--	-----	----

Only six animals died en route during the entire short-haul testing period. These were equally divided between the sprinkled and unsprinkled trucks. Four dead were found in the lots originating in Mattoon and two in lots from Bloomington. Because of the infrequency of occurrence and equal distribution among all shipments, mortality losses were disregarded as a factor affected by sprinkling under these conditions.

Cripples found on arrival were likewise equally distributed, and there were only four cases. They are disregarded in the results for the same reasons as reported for mortality.

Advantages and Disadvantages

The sprinkling system tested during 1957 proved to be economical to install. However, its disadvantages are such that it cannot be generally recommended. Its use should be confined to those operations which cannot justify a higher cost installation or those in which the additional effort required of the driver is not a problem.

The following factors should be carefully considered by any prospective user:

Advantages:

1. Low initial cost.
2. Ease of installation.
3. Light in weight.
4. Low maintenance cost.
5. Deck boards can be removed without disturbing the spray headers.

Disadvantages:

1. Water for sprinkling must be supplied from an outside source.
2. Many roadside businesses, such as small gas stations or diners, would object to a livestock truck parking to spray the load.
3. Sprinkling generally is confined to those times when the driver makes his regular stops to refuel or eat at a conventional truck stop.

## Disadvantages--Continued

4. A large number of small holes must be placed in the headers to provide adequate coverage of the entire cargo area.
5. Sufficient water pressure must be available for complete coverage of both decks when sprinkling.
6. The spray streams deliver a larger total volume of water than spray nozzles. Most of this excess is ineffective and accumulates on the floor, producing a slippery footing.
7. The spray holes are easily clogged by small particles of material which may appear in the water.
8. Drivers are reluctant to stop and spray as often as they should because of the time consumed and the extra effort required to hook up the water supply.

## CONCLUSIONS AND RECOMMENDATIONS

The data collected during this 3-year testing period show that under certain conditions of temperature and length of trip, substantial savings can be derived from in-transit sprinkling of hogs. These savings result from lower mortality, less transit shrink, and higher dressing yields.

The greatest benefits were found on the long-haul trips of 27 hours when the sprinkling was performed at half-hour intervals and the temperature at sprinkling time averaged 81° F. Less advantage was found on the 11-hour trip when the animals were sprinkled at 2-hour intervals at an average temperature at sprinkling time of 83°. The short-haul trip of 5 hours in which the hogs were sprinkled 3 times en route when the average temperature at sprinkling time was 77° showed no significant advantage in favor of sprinkling. A summary of the advantages appears in table 1.

On the basis of the data collected and observations made throughout these tests, it is recommended that sprinkling live hogs in transit be considered by any shipper or trucker moving hogs at temperatures of 80° F. or above. At 80° or above, the hogs seemed to enjoy the cooling effects of the sprinkling, as indicated by a more quiet and contented load. Under these conditions, the possibilities of mortality and bruising from trampling or crowding are greatly reduced.

Length of haul should not be used as a single criterion to determine whether or not sprinkling is advantageous. Test results on the 5-hour trip showed no significant advantage; however, the average ambient temperature at time of sprinkling on those trips was 77° F. The effectiveness of sprinkling advances with increases in the temperature and in the number of hours the animals are on the truck. On a hot day with temperatures in the nineties or above, sprinkling should be highly effective in reducing losses, even on a short trip. A delay in city traffic or at unloading time at 90° or above may result in a loss regardless of the length of haul. Temperature, length of trip, and the conditions under which the trip is made must always be considered jointly in determining the advisability of sprinkling.

Table 1.--Summary of results for all tests (1956-58) showing advantages in favor of sprinkling

Length of haul	Transit shrink advantage 1/	Hot slaughtered yield advantage 1/	Average number of dead per load	Av. outside: temp. when hogs were sprinkled	Interval : between : sprin- kled	No. times hogs were sprin- kled
	Percent	Pounds	Percent	Pounds	Number	°F.
					Number	Hours
Long-haul						
2/ .....	+1.11	+361	+56	+182	0	.80
Medium-haul						
3/ .....	+1.03	+226	+47	+103	0	.38
Short-haul						
4/ .....	+23	+64	+07	+19	.04	.77
Short-haul						
5/ .....	+19	+52	-.07	-19	.10	.77

1/ + denotes advantage in favor of sprinkling; - denotes advantage in favor of not sprinkling.  
2/ 27 hours (1958), Lafayette, Ind., to New Haven, Conn., 15 tests, 153 hogs per load.  
3/ 11 hours (1956), Smithfield, N. C., to Baltimore, Md., 16 tests, 111 hogs per load.  
4/ 5 hours (1957), Bloomington, Ill., to E. St. Louis, Ill., 23 tests, 127 hogs per load.  
5/ 5 hours (1957), Mattoon, Ill., to E. St. Louis, Ill., 22 tests, 123 hogs per load.

All of the sprinkling systems designed and used during these tests proved satisfactory. Each had its advantages and disadvantages. The decision of the prospective user as to which system to install, therefore, should be based on the conditions of his individual operations. Factors to be considered include initial cost, maintenance, added weight on the truck, length of haul, temperatures encountered, availability of water en route, and frequency of expected use.

Both of the manually operated systems require an outside water supply, which makes them less desirable for long-haul trips because frequent stops would mean too much delay. However, they can be effective if the user is willing to exert the extra effort required to sprinkle and can afford to spend the time for frequent stops en route. The choice between the single spray header in the center of each deck or the double header on each side is mainly contingent on the frequency with which the deck boards are removed. The hauler traveling medium or short distances may find that the extra effort required to sprinkle and the time lost en route is not objectionable when he uses either of the manually operated systems. Conversely, these same haulers may find it advantageous to use the more expensive semiautomatic system if they run close schedules and experience long periods of hot weather.

Probably the most practical system for the trucker who does not encounter much hot weather and cannot justify the cost of the other systems is the installation of one lawn-soaker hose on each deck. For the few occasions when sprinkling would be beneficial, this system offers a low-cost, easily installed unit.

The system most adaptable to medium or long trips in warm weather is the semiautomatic type, using a reservoir tank and spray nozzles. Its versatility of operation and freedom from reliance on an outside water supply make it most practical. Sprinkling can be done by the turn of a switch in the cab, at any time en route when its effect is beneficial. The spray nozzles also enhance the desirability of the system because they conserve water and provide complete coverage. Although the initial cost of the semiautomatic system is relatively high, it can be justified by the benefits derived over a reasonable period of time. A trucker can readily accomplish his objectives in sprinkling with this unit, and therefore its use is recommended whenever there are substantial losses in transit caused by high temperatures.

# APPENDIX

Table 2.--Data collected during 1958 hog sprinkling tests (Lafayette, Ind., to New Haven, Conn.)

		Hogs															
Date	Test: No.	Live weight when				Percentage of				Hot slaughtered				Percentage			
		Loaded	Unloaded	Shrinkage	transit	shrinkage in	transit	shrinkage in	transit	weight	Un-	Sprin-	Un-	hot yield	Un-	Sprin-	Un-
		Pounds	Pounds	Pounds	Pounds	Pct.	Pct.	Pounds	Pounds	Pounds	kled	kled	kled	kled	kled	kled	kled
1958		Pounds	Pounds	Pounds	Pounds	Pct.	Pct.	Pounds	Pounds	Pounds	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	No.
July 28	1	31,930	32,750	30,165	30,780	5.53	6.02	22,969	23,259	71.94	71.02	-	-	-	-	-	0
" 29	2	32,260	32,300	30,070	30,675	6.79	5.03	23,138	23,430	71.72	72.54	-	-	-	-	-	0
Aug. 4	3	32,250	32,620	30,360	31,065	5.68	4.77	-	-	-	-	2.83	1.76	3/1	0	0	0
" 5	4	32,410	31,890	30,475	30,775	5.94	3.50	23,328	23,441	71.98	73.51	-	-	-	-	-	0
" 6	5	32,250	32,300	29,805	30,205	7.58	6.49	22,702	23,017	71.26	71.26	1.91	2.50	1	0	0	0
" 11	6	32,770	32,900	30,070	30,790	8.24	6.41	22,896	23,489	69.87	71.40	1.86	1.11	2	0	0	0
" 12	7	31,800	32,640	30,460	30,715	4.21	5.90	22,997	23,049	72.32	70.62	1.52	1.11	0	0	0	0
" 13	8	32,710	32,400	29,105	30,850	11.02	4.78	21,495	23,162	65.71	71.49	-	-	5	0	0	0
" 18	9	32,300	32,480	30,915	30,565	4.29	5.90	23,219	22,957	71.89	70.68	1.75	1.82	0	0	0	0
" 19	10	32,560	32,530	30,485	30,553	6.37	6.08	23,113	23,163	70.99	71.21	1.65	1.08	0	0	0	0
" 25	11	32,550	33,050	30,470	30,925	6.39	6.43	22,890	23,109	70.32	69.92	1.97	2.00	0	4/0	0	0
" 26	12	33,250	33,200	30,975	31,255	6.84	5.86	23,686	23,359	71.36	70.36	2.33	2.49	0	0	0	0
" 27	13	32,500	32,400	30,395	30,745	6.48	5.17	22,906	23,329	70.48	71.96	2.85	2.57	0	0	0	0
Sept. 2	14	33,340	33,000	31,225	31,025	6.34	5.98	23,676	23,558	71.01	71.39	2.44	1.74	0	0	0	0
" 3	15	33,200	33,100	30,200	31,125	9.04	5.97	23,282	23,547	70.12	71.14	1.68	2.28	1	0	0	0
Average		32,539	32,639	30,345	30,803	6.74	5.63	23,021	23,276	70.75	71.31	2.07	1.85	0.8	0	0	0

1/ Both trucks carried the same number of hogs on each test. The average number for all tests was 153.

2/ A sample of 10 carcasses were weighed hot and then reweighed when chilled the following day.

3/ Died in pen a few minutes after unloading.

4/ One hog arrived dead on this shipment but was not included in the results since it had a broken leg when loaded and should have been excluded at the shipping point.

Table 3.--Temperature and sprinkling data for long-haul tests (1958)

Date	Test No.	Outside air during trip			Average inside temperature <u>2/</u>		Number of times sprinkled en route	Average outside temperature when sprinkled <u>3/</u>
		Max.	Ave. <u>1/</u>	Min.	Sprinkled	Un-sprinkled		
1958		°F.	°F.	°F.	°F.	°F.	Number	°F.
July 28	1	90	77.5	66	77.8	80.0	28	82
" 29	2	90	80.0	70	-	-	34	83
Aug. 4	3	90	82.2	70	75.6	77.6	28	85
" 5	4	88	73.7	56	-	-	12	84
" 6	5	90	78.5	66	79.3	79.3	28	84
" 11	6	85	75.6	65	76.6	78.0	14	80
" 12	7	90	78.4	66	82.0	83.9	23	84
" 13	8	86	74.7	66	75.8	82.8	16	80
" 18	9	78	65.3	50	69.2	67.8	4	77
" 19	10	84	70.0	48	70.5	75.6	17	80
" 25	11	78	65.0	40	66.3	66.8	1	78
" 26	12	79	68.5	48	71.3	78.0	10	78
" 27	13	80	67.6	56	-	-	5	77
Sept. 2	14	80	67.2	50	72.1	71.0	3	78
" 3	15	86	75.3	64	75.1	78.1	13	82
Average		85	73.3	59	74.3	76.6	16	81

1/ Average of 1-hour interval readings taken from recording thermometer charts.

2/ Average of top and bottom deck temperatures taken from 1-hour interval readings on recording thermometer charts.

3/ Temperature taken with stick thermometer at time of sprinkling.

Table 4.-- Cooler shrink on sample carcasses (1958)

Test No.	Size of sample		Hot-carcass weight		Cold-carcass weight		Percent shrink	
	Un-sprinkled	Sprinkled	Un-sprinkled	Sprinkled	Un-sprinkled	Sprinkled	Un-sprinkled	Sprinkled
	<u>Number</u>	<u>Number</u>	<u>Pounds</u>	<u>Pounds</u>	<u>Pounds</u>	<u>Pounds</u>	<u>Pct.</u>	<u>Pct.</u>
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	8	10	1,169	1,534	1,136	1,507	2.83	1.76
4	-	-	-	-	-	-	-	-
5	10	10	1,519	1,522	1,490	1,484	1.91	2.50
6	10	9	1,504	1,444	1,476	1,428	1.86	1.11
7	8	10	1,249	1,439	1,230	1,423	1.52	1.11
8	-	-	-	-	-	-	-	-
9	6	6	812	881	798	865	1.75	1.82
10	9	9	1,452	1,394	1,428	1,379	1.65	1.08
11	9	9	1,323	1,351	1,297	1,324	1.97	2.00
12	7	7	988	1,044	965	1,081	2.33	2.49
13	9	8	1,406	1,246	1,366	1,214	2.85	2.57
14	8	8	1,275	1,211	1,244	1,190	2.44	1.74
15	8	8	1,137	1,230	1,118	1,202	1.68	2.28
Average			1,258	1,300	1,232	1,276	2.07	1.85

Table 5.--Data collected during 1957 hog sprinkling tests (Bloomington, Ill., to East St. Louis, Ill.)

		Hogs															
Date	Test No.	Live weight when				Percentage				Hot				Percentage			
		Loaded	Unloaded	Un-	Un-	of shrinkage	in transit	Un-	Sprin-	slaughtered	Un-	Sprin-	Un-	hot yield	Un-	Sprin-	Dead
		Un-	Sprin-	Sprin-	Sprin-	Un-	Sprin-	Un-	Sprin-	Un-	Sprin-	Un-	Sprin-	Un-	Sprin-	Un-	carcasses unloaded
		kled	kled	kled	kled	kled	kled	kled	kled	kled	kled	kled	kled	kled	kled	kled	kled
		Pounds	Pounds	Pounds	Pounds	Pct.	Pct.	Pounds	Pounds	Pounds	Pct.	Pct.	Pct.	Pct.	No.	No.	No.
1957																	
June 12	1	30,590	30,520	29,680	29,550	2.97	3.17	23,868	23,809	68.27	68.26	146	146	0	0	0	0
" 13	2	30,780	30,720	29,970	29,790	2.63	3.03	24,291	23,909	69.05	68.10	142	142	0	1	0	1
" 17	3	30,740	30,780	29,730	29,800	3.28	3.18	24,152	24,102	68.75	68.52	136	136	0	0	0	0
" 18	4	23,690	23,680	23,070	22,890	2.62	3.34	18,521	18,622	68.41	68.81	97	97	0	0	0	0
" 24	5	28,760	28,780	27,970	28,090	2.75	2.40	22,492	22,573	68.43	68.63	118	118	0	0	0	0
" 25	6	29,600	29,530	28,710	28,710	3.01	2.78	23,402	23,356	69.18	68.21	129	129	0	0	0	0
" 26	7	28,970	29,020	27,980	28,340	3.42	2.34	22,708	22,665	68.59	68.34	137	137	1	0	0	0
" 27	8	26,860	26,850	26,100	26,260	2.83	2.20	21,058	20,895	68.60	68.09	106	106	0	0	0	0
July 8	9	27,820	27,860	26,930	27,020	3.20	3.01	21,711	21,865	68.29	68.67	127	127	0	0	0	0
" 9	10	29,050	28,970	28,290	28,280	2.62	2.38	22,864	22,889	68.87	69.13	142	142	0	0	0	0
" 11	11	28,550	28,480	27,740	27,800	2.84	2.39	22,499	22,370	68.96	68.73	114	114	0	0	0	0
" 15	12	24,400	24,490	23,760	23,860	2.62	2.57	19,012	19,218	68.18	68.66	115	115	0	0	0	0
" 16	13	26,320	26,300	25,480	25,620	3.19	2.59	20,481	20,503	68.09	68.21	123	123	0	0	0	0
" 17	14	30,010	30,050	29,100	29,310	3.03	2.46	23,087	23,386	67.31	68.10	154	154	0	0	0	0
" 18	15	29,690	29,680	28,750	28,800	3.17	2.96	-	-	-	-	140	140	0	0	0	0
" 23	16	29,720	29,680	28,760	28,850	3.23	2.80	23,191	23,261	68.28	68.57	138	138	0	0	0	0
" 29	17	26,230	26,270	25,420	25,600	3.09	2.55	20,620	20,780	68.78	69.21	119	119	0	0	0	0
" 31	18	27,480	27,430	26,680	26,700	2.91	2.66	21,764	21,687	69.30	69.18	118	118	0	0	0	0
Aug. 1	19	28,030	29,020	27,160	27,130	3.10	3.18	22,102	22,044	68.99	68.84	133	133	0	0	0	0
" 5	20	29,620	29,640	28,760	29,040	2.91	2.02	23,163	23,275	68.43	68.78	120	120	0	0	0	0
" 6	21	27,890	27,890	27,080	27,120	2.90	2.76	21,996	21,874	69.01	68.62	127	127	0	0	0	0
" 7	22	25,470	25,520	24,720	24,820	2.94	2.74	19,994	19,999	68.69	68.57	116	116	0	0	0	0
" 8	23	29,410	29,350	28,570	28,510	2.86	2.86	23,081	22,943	68.67	68.40	135	135	0	0	0	0
Average		28,247	29,240	27,409	27,473	2.96	2.71	22,117	22,092	68.60	68.62	127	127	0.04	0.04	0.04	0.04

Table 6.--Temperature and sprinkling data for short-haul tests (1957) from  
Bloomington, Ill.

Date	Test No.	Outside air during trip			Average inside temperature <sup>2/</sup>		Number of times sprinkled en route	Average out- side temper- ature when sprinkled <sup>3/</sup>
		Max.	Ave. <u>1/</u>	Min.	Sprin- kled	Un- sprin- kled		
1958		°F.	°F.	°F.	°F.	°F.	Number	°F.
June 12	1	80	71.6	63	78.0	79.6	3	68
" 13	2	75	72.2	69	76.7	78.6	3	70
" 17	3	83	79.5	73	84.7	88.0	3	80
" 18	4	76	71.4	67	82.6	82.2	3	73
" 24	5	71	66.5	61	70.4	70.9	2	68
" 25	6	84	75.4	67	80.7	78.6	3	78
" 26	7	80	72.1	73	76.5	78.3	3	73
" 27	8	74	71.0	68	73.1	77.5	2	71
July 8	9	78	83.3	65	85.8	88.1	3	74
" 9	10	86	72.7	66	80.3	83.8	2	77
" 11	11	89	80.9	73	83.9	85.1	3	85
" 15	12	83	75.9	70	80.4	84.2	2	82
" 16	13	85	79.5	76	79.8	83.3	3	80
" 17	14	89	87.1	84	85.7	88.8	3	87
" 18	15	87	81.9	77	79.2	84.2	3	88
" 23	16	81	77.5	73	73.0	77.8	3	79
" 29	17	83	78.0	75	79.1	80.3	3	83
" 31	18	94	78.3	75	82.5	80.0	3	82
Aug. 1	19	74	72.4	69	75.8	78.2	2	77
" 5	20	83	70.5	64	72.1	70.9	3	72
" 6	21	89	73.5	64	73.7	74.7	3	78
" 7	22	82	76.0	72	75.4	79.6	3	77
" 8	23	93	82.8	73	84.8	83.9	3	82
Average		83	76.1	70	78.9	80.7		77

<sup>1/</sup> Average of 1-hour interval readings taken from recording thermometer charts.

<sup>2/</sup> Average of top and bottom deck temperatures taken from 1-hour interval readings on recording thermometer charts.

<sup>3/</sup> Temperature taken with stick thermometer at time of sprinkling.

Table 7.--Data collected during 1957 hog sprinkling tests (Mattoon, Ill., to East St. Louis, Ill.)

Hogs																	
Date	Test No.	Live weight when				Percentage				Hot		Percentage		Number hogs		Dead	
		Loaded		Unloaded		of shrinkage		in transit		slaughtered weight	hot yield	on trailer	carcasses unloaded	carcasses unloaded			
		Un- sprin- kled	Sprin- kled	Un- sprin- kled	Sprin- kled	Un- sprin- kled	Sprin- kled	Un- sprin- kled	Sprin- kled						Un- sprin- kled	Sprin- kled	
		Pounds	Pounds	Pounds	Pct.	Pct.	Pct.	Pct.	Pounds	Pct.	Pct.	No.	No.	No.	No.	No.	No.
1957																	
June 18	1	27,480	27,540	26,550	26,530	3.38	3.67	21,817	21,583	69.47	68.57	95	95	0	0	0	0
" 20	2	27,430	27,450	26,670	26,750	2.77	2.55	21,419	21,756	68.32	69.38	115	116	0	0	0	0
" 25	3	27,370	27,430	26,540	26,740	3.03	2.52	21,864	21,925	69.90	69.94	117	118	0	0	0	0
" 27	4	27,790	27,640	26,840	26,660	3.42	3.55	21,681	21,586	68.27	68.33	131	130	0	0	0	0
July 2	5	26,840	26,880	25,840	26,025	3.73	3.18	20,840	20,936	67.94	68.15	112	112	0	0	0	0
" 9	6	26,530	26,460	25,660	25,720	3.28	2.80	-	-	-	-	118	119	0	0	0	0
" 11	7	25,980	26,020	24,960	24,990	3.93	3.96	20,085	20,242	67.64	68.07	123	123	0	0	0	0
" 16	8	27,520	27,600	26,580	26,780	3.42	2.97	21,448	21,404	68.19	67.86	137	137	0	0	0	0
" 18	9	27,650	27,660	26,930	26,790	2.60	3.15	21,705	21,622	68.68	68.40	120	120	0	0	0	0
" 23	10	27,480	27,530	26,650	26,750	3.02	2.83	21,397	21,681	68.13	68.91	119	119	0	0	0	0
" 25	11	27,260	26,490	26,360	25,440	3.30	3.96	21,335	20,761	68.48	68.58	123	120	0	2	0	2
" 30	12	27,420	27,510	26,430	26,815	3.61	2.53	18,621	18,856	67.91	68.54	143	142	1	0	0	0
Aug. 1	13	27,550	27,520	26,490	26,620	3.85	3.27	21,575	21,580	68.52	68.61	129	128	0	0	0	0
" 6	14	26,980	26,960	26,210	26,050	2.85	3.38	21,091	21,044	68.40	68.30	133	133	0	0	0	0
" 8	15	27,320	27,400	26,450	26,220	3.18	4.31	21,918	21,262	70.20	67.90	120	121	0	0	0	0
" 13	16	27,250	27,320	26,360	26,490	3.27	3.04	21,178	21,228	68.00	67.99	138	138	0	0	0	0
" 15	17	27,640	27,730	26,320	26,850	4.78	3.17	21,164	21,216	66.99	66.94	137	137	1	0	0	0
" 20	18	27,630	27,640	26,820	26,890	2.93	2.71	21,418	21,051	67.83	66.64	110	110	0	0	0	0
" 22	19	27,630	27,530	26,830	26,800	2.90	2.65	21,761	21,761	68.91	68.87	104	104	0	0	0	0
" 27	20	27,700	27,820	27,160	27,160	2.92	2.37	21,468	21,571	67.81	67.85	123	123	0	0	0	0
" 29	21	27,680	27,670	27,040	26,720	2.31	3.43	21,463	21,575	67.85	68.23	118	119	0	0	0	0
Sept. 3	22	27,670	27,750	26,940	27,050	2.64	2.52	21,552	21,395	68.15	67.46	134	135	0	0	0	0
Average		27,355	27,325	26,471	26,493	3.23	3.11	21,276	21,235	68.36	68.26	123	123	0.10	0.10	0.10	0.10

Table 8.--Temperature and sprinkling data for short-haul tests (1957) from Mattoon, Ill.

Date	Test No.	Outside air during trip			Average inside temperature <u>2/</u>		Number of times sprinkled en route	Average outside temperature when sprinkled <u>3/</u>
		Max.	Ave. <u>1/</u>	Min.	Sprinkled	Un-sprinkled		
<u>1958</u>		<u>°F.</u>	<u>°F.</u>	<u>°F.</u>	<u>°F.</u>	<u>°F.</u>	<u>Number</u>	<u>°F.</u>
June 18	1	74	69.9	64	72.1	73.4	3	69
" 20	2	76	70.5	63	78.0	76.1	3	69
" 25	3	75	72.9	67	78.2	79.2	3	73
" 27	4	70	68.0	66	68.3	78.6	2	69
July 2	5	80	72.7	66	81.4	85.2	3	74
" 9	6	80	73.5	68	80.2	82.2	2	75
" 11	7	85	78.1	70	84.0	84.9	2	85
" 16	8	76	74.0	70	85.4	82.1	3	75
" 18	9	99	77.8	73	81.8	84.0	3	84
" 23	10	75	70.7	67	83.6	77.1	3	72
" 25	11	81	75.7	71	80.8	81.6	3	79
" 30	12	-	-	-	-	-	3	82
Aug. 1	13	74	72.9	71	78.6	83.8	2	73
" 6	14	96	72.9	63	73.0	75.7	3	77
" 8	15	90	83.9	75	85.5	85.0	3	84
" 13	16	97	81.3	71	85.3	85.5	3	81
" 15	17	89	84.7	78	86.4	88.2	3	84
" 20	18	84	74.7	66	72.2	77.3	3	78
" 22	19	85	76.3	67	78.1	81.8	3	78
" 27	20	74	70.1	65	74.6	71.0	3	-
" 29	21	90	83.3	77	89.3	85.9	3	77
Sept. 3	22	85	75.8	67	81.8	81.7	3	77
Average		83	75.4	69	79.9	81.0		77

1/ Average of 1-hour interval readings taken from recording thermometer charts.

2/ Average of top and bottom deck temperatures taken from 1-hour interval readings on recording thermometer charts.

3/ Temperature taken with stick thermometer at time of sprinkling.



